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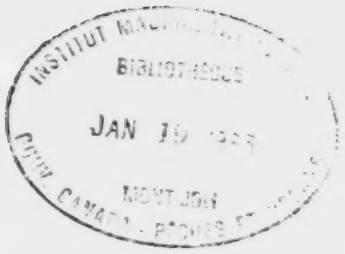

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The economics of seals in the eastern Canadian arctic

by

I. A. McLaren

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SUMMARY

This report is a preliminary enquiry into the economics of seal hunting in the eastern Canadian arctic, written partly as a plea for more information. Of the five species found in the area (the ringed, bearded, harp, harbour and hooded seals) only the ringed and bearded seals are of much economic importance. The field marks and essential biology of the species are outlined.

An analysis is made of the maximum sustained yields of ringed and bearded seals. Life tables have been constructed for the ringed seal which suggest a safe maximum sustained yield of 8 per cent of the population per year. Comparable analyses cannot be made for the bearded seal, although a figure of 5 per cent per year is suggested as being wholly safe.

A method of censusing seals from shipboard is outlined, that more systematic accounts of seal abundance may be available. The method appears to give consistent underestimates of seal numbers, and to improve it more information is needed on limits of visibility and durations of seals' dives.

Under-utilized populations of ringed seals appear to be limited by the amounts and qualities of fast ice available for the breeding adults. More complex coasts are much better supplied with seals. On the basis of a few censuses and observations of seals on the ice, a quantitative relationship between areas of fast ice and numbers of seals is developed. Good breeding ice within one mile of shore is presumed to reflect a population of 35 seals per square geographical mile; less suitable ice, 10 per square mile; ice more than one mile off, 5 per square mile. The fast ice in these categories has been measured on topographic (8-mile-to-1-inch) maps, and populations of seals are tabulated for coastlines south of Lancaster Sound in the eastern arctic. The differences in seal populations demonstrated in this way reflect very well the known conditions for hunting in different regions. A population of close to a million ringed seals is implied for this portion of the eastern arctic.

A less arbitrary indication of seal abundance is the availability index. For summer, we may derive such an index by dividing the hypothetical population on a coastline by the area of water within 10 miles of shore. The figures thus derived compare quite well with the results of a few summertime censuses from shipboard. A more complex treatment is necessary to derive an index of availability of seals at the floe edge in winter.

Only young seals are represented here, and their numbers are modified by amounts of fast ice and complexity of coastlines. The figures tabulated from this analysis are less reliable, and further observations and collections are needed. The availability index of seals killed on the fast ice in spring is based on seasonal and latitudinal effects on the numbers of seals basking on the ice, and is presented graphically. The availability of seals at breathing-holes and tide-rips cannot be analysed in the same mechanistic manner.

Availability indices are made more meaningful when converted into catch per unit effort. The results of 40 summer hunts, 16 floe-edge hunts, and 19 fast-ice hunts are available. More are needed for greater reliability, but useful information can be derived at present. For example, it appears that a powered canoe has about twice the catch per unit effort per hunter of the Peterhead schooner, although the latter produces more per boat, and thus has smaller overhead. Local modifications of the availability of ringed seals are discussed: including breeding concentrations, effects of dispersal, offshore and inshore concentrations, feeding concentrations, local hunting effects, and climate.

There is as yet no key to the distribution and availability of bearded seals comparable to that developed for the ringed seal. The species is most common where shallow water extends well out beyond the limit of fast ice in winter, particularly in Ungava Bay and Hudson Bay. An attempt is made to estimate numbers of bearded seals by comparing the abundance of this species and the ringed seal in a few censused areas. For the same coastlines dealt with in the ringed seal studies, populations of bearded seals, sustainable yields, and catches per unit effort are tabulated. A population of about 185,000 animals is suggested for the eastern arctic.

In utilizing seal populations, it is not sufficient merely to consider numbers and availabilities, for there are many variables which affect the yield of seal carcasses. The relationship between length and weight is formulated for ringed and bearded seals. The size of ringed seals varies considerably in catches from different eastern arctic localities (varying essentially with latitude), in different seasons, and in different local areas along the same coastline. The variations are discussed and tabulated. The bearded seal does not show this variation, the average probably being about 465 pounds wherever found. About 30 per cent of a seal of average summer fatness is edible meat and fat for humans; another 8-9 per cent can be

eaten by dogs. The amount of food available from the average seal together with availability index and maximum sustained yield give a fairly complete picture of hunting conditions for any coastline.

The fat yield shows a marked seasonal variation, modified by latitude. The ringed seal may be 40 per cent fat by weight in mid winter and only 23 per cent at the peak of starvation in spring. The bearded seal varies somewhat less, but averages thinner. The seasonal and latitudinal variation is accounted for graphically.

The yield of seal skins is discussed. Whitecoat hunting is not to be discouraged in regions where it is an occasionally valuable resource (Cumberland Sound especially). The ringed seal young of the year ("silver jar") is the most valuable skin, and varies between 15-20 per cent of the catch on most coastlines, but it can be selectively hunted. The variation in proportion of silver jars locally and seasonally is tabulated. Other skins are discussed briefly.

The loss of seals through sinking is a serious problem to the seal hunter. Loss is a function of seasonal changes in blubber thickness and differences in sea water density at the surface. The time of greatest loss varies, essentially, with latitude. All these factors are combined graphically, so that the proportion of seals lost may be estimated for any region, date, and sea water density. Some methods of overcoming the loss of seals are discussed.

A limited discussion of hunting methods is offered, in the light of the preceding quantitative analyses, in the four categories of boats, rifles, seal nets, and seal hooks and set-guns.

Practical use of the tables and graphs is demonstrated by a section answering a series of specific questions. The questions range from simple to complex ones demanding use of several tables and graphs in conjunction.

Finally, a list of methods of collecting and recording valuable information and material is offered. Many of the analyses are based on limited observations and samples, and it is hoped that northern residents can supply much of what is needed.

INTRODUCTION

This report is offered as a first attempt at an economic analysis of seal hunting in the eastern Canadian arctic. As anyone who has been in the North will know, the problem is an extremely complex one, involving elements of technology, seal biology, geography, weather, sociology, psychology and numerous other variables. Though some of the analyses presented herein are based on few data, it is considered that they are more nearly accurate than mere guesses.

The report has been written for three main purposes:

1. With all its shortcomings, it may be used for assessing the potential seal production of particular areas. The tables and graphs can give a precise definition of many of the problems of inhabited areas, or they may be used in predicting the suitability of areas for new, transplanted communities of Eskimos. They should also be considered in any development of commercial utilization of arctic seals. For those who prefer not to concern themselves with the arguments basic to these tables and graphs, there is a section at the end (see p. 76) giving examples of the ways in which they may be used.

2. The report is not meant to be final. It is written at this stage in order that readers who are familiar with the problems might offer criticism of the assumptions, methods and figures. The author would be very grateful to receive such criticism in order that a future report may be more firmly based.

3. Granted the possibility that the methods used in this report are sound, it will be seen that many of the actual figures used are from very limited samples or areas. The more quantitative information which we can gather, the more likely are the analyses and predictions to be correct. The report is written, then, as a plea for more information from more areas. To make this task easier, there is a section at the end listing the precise methods of recording useful information and gathering materials.

DESCRIPTION AND ESSENTIAL BIOLOGY OF THE SPECIES

There are four species of seals found regularly in the eastern Canadian arctic. Of these, the harp seal (Phoca groenlandica), or kaerolik of the Eskimos, is an abundant

RINGED SEAL

Pelage marbled, or ringed, generally more silvery than harbour seal. Head not as dog-like as harbour seals. Length of adult averaging 4 1/2 feet from tip of nose to tail.

Fig. 1

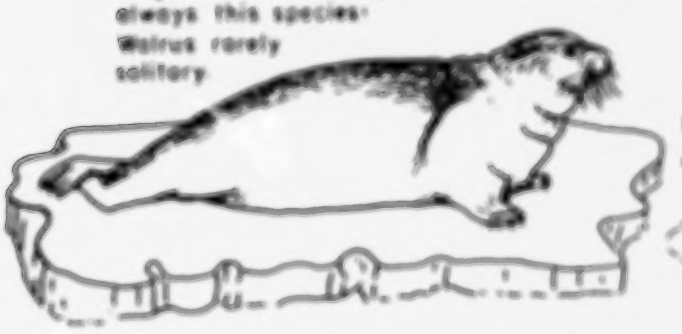
The only seal to lie out on the fast ice in spring, where adults and some young keep breathing holes in winter. Very rare on pack ice.

Generally inactive on surface, swimming slowly, moving head, sometimes pointing nose skyward. May tread water when close for a better look; the head appears dark and the chest light silvery when it does this. Does not generally roll when diving, but large seals may show a little of back.

BEARDED SEAL

Eyes grey, slightly darker on back.
Length of adult averaging 7 1/2 - 8 feet

Large even-coloured light seals on ice pans always this species. Walrus rarely solitary.



long, glistening white whiskers, often show from afar

back almost always out of water

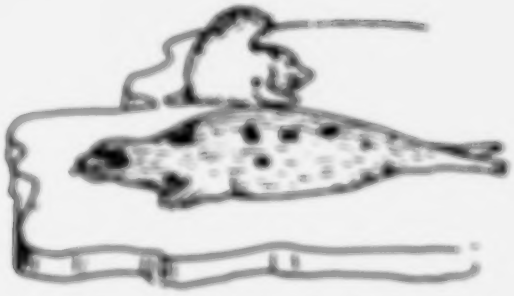
rolls over when diving

Field marks of ringed and bearded seals.

HARP SEAL

Old males with saddle mark on back, females similar but subdued. Young with irregular dark blotches. Length of adult about 5 1/2 feet

Very active, often bobbing up and down, even leaping right out of water.



Often on ice pans, offshore, unlike ringed seal.

Generally travelling in schools on migration, moving in a constant direction, leaping and cavorting like porpoises and swimming on backs! Found in arctic only in summer

Fig. 2

HARBOUR SEAL

Very heavily spotted in eastern arctic. Often almost black. Length of adult about 5 feet.

Often comes out on shore; only arctic species regularly doing so.

Head more dog-like and heavier than ringed seal.

More active and playful than ringed seal. Swims about, often in circles, extending flippers, rolls and leaps.

Found in small colonies in some areas
Often around large rivers and goes into fresh water, found rarely wintering at floe edge (Hudson Bay) or in certain tide rips (Baffin Island).

Field marks of harp and harbour seals.

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migrant to the eastern arctic in summer, but is not commonly taken by the hunter. The harbour, or ranger seal (Phoca vitulina) is a rare resident in the more southerly regions of the arctic; known as kassigiark to the Eskimo, it is prized for its dark and beautiful skin. The ringed, or jar seal (Phoca hispida) is the ubiquitous netserk (netsik, netjerk) of the Eskimos, and is the seal of the Eskimo economy. The bearded seal, or squareflipper, (Erignathus barbatus) is rather sparsely distributed; it is the ugjuk (udjuk, ugruk) of the Eskimos and it supplies much meat and important leather products. There is a fifth species, the hooded seal (Cystophora cristata), or netsivak of the Eskimos, which is very rare and found only at all regularly in the northeastern corner of Baffin Island. The general appearance and field marks of the first four species are shown in Figures 1 and 2.

Dunbar (1949) reviews the biology of all the above species and others of the arctic and subarctic. The ringed seal and the bearded seal are really the only two of much economic importance in the north, and basic features of their biology will be outlined here before going on to the more directly economic problems. The biological data which follow are largely abstracted from two papers by the author (McLaren, 1958a and 1958b).

Basic to our understanding of the life histories of ringed and bearded seals has been the use of accurate methods of age determination. The methods will not be described in detail; it is sufficient to say that the ringed seal may be aged by dentinal annuli in the canine teeth and by bands on the claws, whereas the bearded seal may be aged from its claws alone. Both tooth and claw patterns depend on annual metabolic interruptions, caused by fasting, the moult, and reproduction in older seals.

The feeding of these two seals has been studied in some detail. The ringed seal feeds on a variety of plankton (small, floating, shrimp-like forms), benthos (bottom animals) and pelagic food (mostly fish), but does not take the large, burrowing or sedentary bottom animals which form almost the entire diet of the bearded seal. The ringed seal varies its food considerably, about 75 species having been found in its diet. The seal may dive to about 50 fathoms, but generally turns from inshore feeding on Mysis (a small shrimp-like animal), prawns, or polar cod, to strictly planktonic food in deeper waters offshore. In southwest Baffin Island its food

in deeper waters is almost exclusively the abundant shrimp-like amphipod, Themisto. Thus, since the diet is chosen from several points in the food chain, it is probably never a limiting factor upon this seal. The seal is often scarce where food is apparently abundant, and we must look elsewhere for distribution factors. The bearded seal, on the other hand, being almost confined to benthonic feeding (it also eats polar cod, which is not an offshore fish), is not found over deep water; it seems most abundant in the arctic where reasonably shallow banks are free of land-fast ice during the winter. Fast ice does not exclude the ringed seal, but the bearded seal appears incapable of maintaining breathing holes in thick ice, although rare exceptions have been recorded.

Both species show a decline of feeding activity in the spring, expressed most strongly in the ringed seal, which lies about basking in the sun during much of May, June and July. The peak of such inactivity generally occurs in late June when the seals are moulting, though the time varies with latitude and with annual climatic change. The fatness of the seal is at its lowest immediately following departure of the fast ice, and many of those killed in early summer by the hunter are lost by sinking.

Our findings on reproduction in these species have been based on sure knowledge of the age of individual animals. In both ringed and bearded seals, the males are mature on the average at seven years. This conclusion is based on testis size and structure, and on size of the baculum (penis bone), which exhibits a spurt of growth in the seventh year. The females of both species mature generally in the sixth or seventh year. We have more information from the ringed seal, in which females are impregnated after a lag of generally a year after first ovulation. About 10 per cent of ringed seals produce a pup when 6 years old, about 50 per cent when 7, 75 per cent when 8, and probably about 90-95 per cent of older females are pregnant each year. These figures are based on conditions of the reproductive tracts and particularly on counts of corpora lutea and their scars, the corpora albicantia, in the ovaries.

In both species, the blastocyst (unattached embryo) does not implant in the uterus and begin to develop until about early August. Since the blastocyst is often very difficult to see at this time, there have been many false assumptions made about the timing of the breeding season. Actually the males of the ringed seal are in rut from March until mid May, and the

females ovulate shortly after producing their pups, while still lactating. Impregnation occurs generally in mid April. The male bearded seal is sexually active a month later; that is to say, the peak of mating occurs in the month of May. Females which have produced pups in early May apparently fail to ovulate until after the rut of the males is finished. Thus a two-year cycle of pup production is established, and the reproductive rate of the bearded seal is considerably smaller than that of the ringed seal.

These considerations of reproduction are somewhat simplified, but are essential to an understanding of the economics of these two seals.

Now the bearded seal lives in the open water the year around and breeds on the pack ice, but the ringed seal adult female needs fast ice, covered with a good depth of snow, for the construction of a pupping lair. These lairs may be hollowed out in drifted snow by the female, or less commonly the females may take advantage of a natural "tent" of ice in pressure ridges near shore. The pup is protected and nurtured here until weaning. Complex skerry and fiord coasts are most suitable for ringed seal pup production since the ice is stable and remains until late in the spring.

In the winter, ringed seals taken at the floe-edge in the open water are exclusively immature; seals taken in peripheral ice of complex coasts, or on the fast ice of simple coasts, are mostly younger adults; those taken in deep bays, well within island-filled regions, and in general in thick, heavily snow-covered ice, are mostly older adults. Experience with age, and possibly competition for more suitable pupping sites, may explain this distribution in adults.

Another fact related to fast ice conditions is that the numbers of small pups among seals of simple coasts are greater. It is believed that earlier weaning of pups is the rule among younger, less experienced mothers dwelling in less stable, less snow-covered ice. In fact, starvelings, the result of premature separation from their mothers, may be common. When it was found that seals of simple coasts of southwest Baffin Island averaged smaller (perhaps 10 cm. shorter as adults) than seals of the same age from nearby more complex coasts, it was presumed that size at weaning directly affected the adult size. Certainly it seems unreasonable to suggest a genetic explanation of this size difference even though the food available to the seals is similar along this 200 miles of coastline.

A similar explanation is offered to account for size differences throughout the ringed seal's wider range. Adult seals of northern Foxe Basin and high arctic localities may average 20 cm. longer than those from southwest Baffin Island, while those from Hudson Bay are smaller than those from southwest Baffin Island. The older females, taking up residence in more suitable fast ice, produce larger, more vigorous pups. These grow into larger adults, which in their turn may produce larger pups. Within limits, then, the effect may be self-perpetuating.

No such geographical size differences have been detected in the bearded seal. Their pups are weaned after a shorter, probably more intense suckling. Perhaps this is linked with the fact that the ice-pack is unstable, and the dangers of separation greater; but at any rate the young bearded seal, abandoned early, is soon able to look after itself.

MAXIMUM SUSTAINED YIELD OF SEALS

The Ringed Seal

If the population of seals in any area is to supply Eskimo needs indefinitely, then the mortality rate imposed by hunting and natural causes must not exceed the reproductive rate. Ricker (1948) has shown that, provided samples of a population are random, the catch curve may be used to calculate the mortality rate. Such a catch curve, fitted to the total sample of seals obtained from southwest Baffin Island in 1953 and 1954, is shown in Figure 3, but it is limited by the following factors which make random sampling impossible:

1. The majority of first-year seals are born in less accessible areas, and do not reach the more heavily hunted areas until they are older.

2. A sample of immature seals in summer will probably be more or less random, though young seals become increasingly wary, and therefore decreasingly catchable, as they grow older. A random sample of young seals may thus be impossible at any season.

3. Older immature seals and recently matured adults probably do not differ in catchability, and should be accurately represented in samples taken in summer.

4. In winter the adult seals and some older immature seals live under the fast ice and do not figure in the hunting kill at the floe edge.

5. Older adult seals begin to withdraw from the more hunted areas progressively with increasing age, retreating to more suitable areas for breeding purposes.

6. Very old seals (15 or more years) do not differ theoretically in catchability. They cannot always be aged accurately, but may be grouped to give mortality rates.

These considerations mean that the total catch curve (Figure 3) probably reflects the mortality rates only in the very old (15 plus years) seals. Though a true mortality rate might also be shown in the catch curve fitted to summer samples of older immature and young adult seals, the catch curves of all other samples reflect differences in catchability, and therefore do not show the true mortality rates.

These limited data, when considered together with reproductive rates, observed hunting mortalities and some assumptions about catchability and natural mortality, enable us to construct a so-called life table. The methods and calculations involved in constructing Table I are summarised in the following paragraph and need only concern the more interested readers. The example deals with a theoretical population in southern Baffin Island (East Bluff to Cape Dorchester), where, in years of high Eskimo initiative, the total kill including losses by sinking are estimated to be 3,000 by the Lake Harbour natives and 4,000 by the Cape Dorset natives.

[The theoretical age composition of the annual kill has been constructed from actual samples taken in southwest Baffin Island in 1953 and 1954 (see McLaren, 1958b) by using smoothed catch curves. Of the 7,000 seals, 5,000 are assumed to be killed between May 1 and October 1, and for these there are adequate samples. On the basis of the distribution of hunters along southern Baffin Island, about 2/3 of these 5,000 will be taken on the more open coasts nearer Lake Harbour and Cape Dorset. Of the remaining 2,000 seals, killed between October and May, probably 1,500 are taken in the open water at the floe edge, and thus are exclusively immature, with full representation of the first-year seals. The remaining 500 are assumed to come from tide rips and breathing holes, and are thus predominantly older seals. In the very old (30 years or more) section of the Table, the increase of natural mortality is rather arbitrarily imposed to dispose of the few remaining seals before the age of 40; only a few seals over 30 years have been taken in many hundreds and only one of over 40 years.

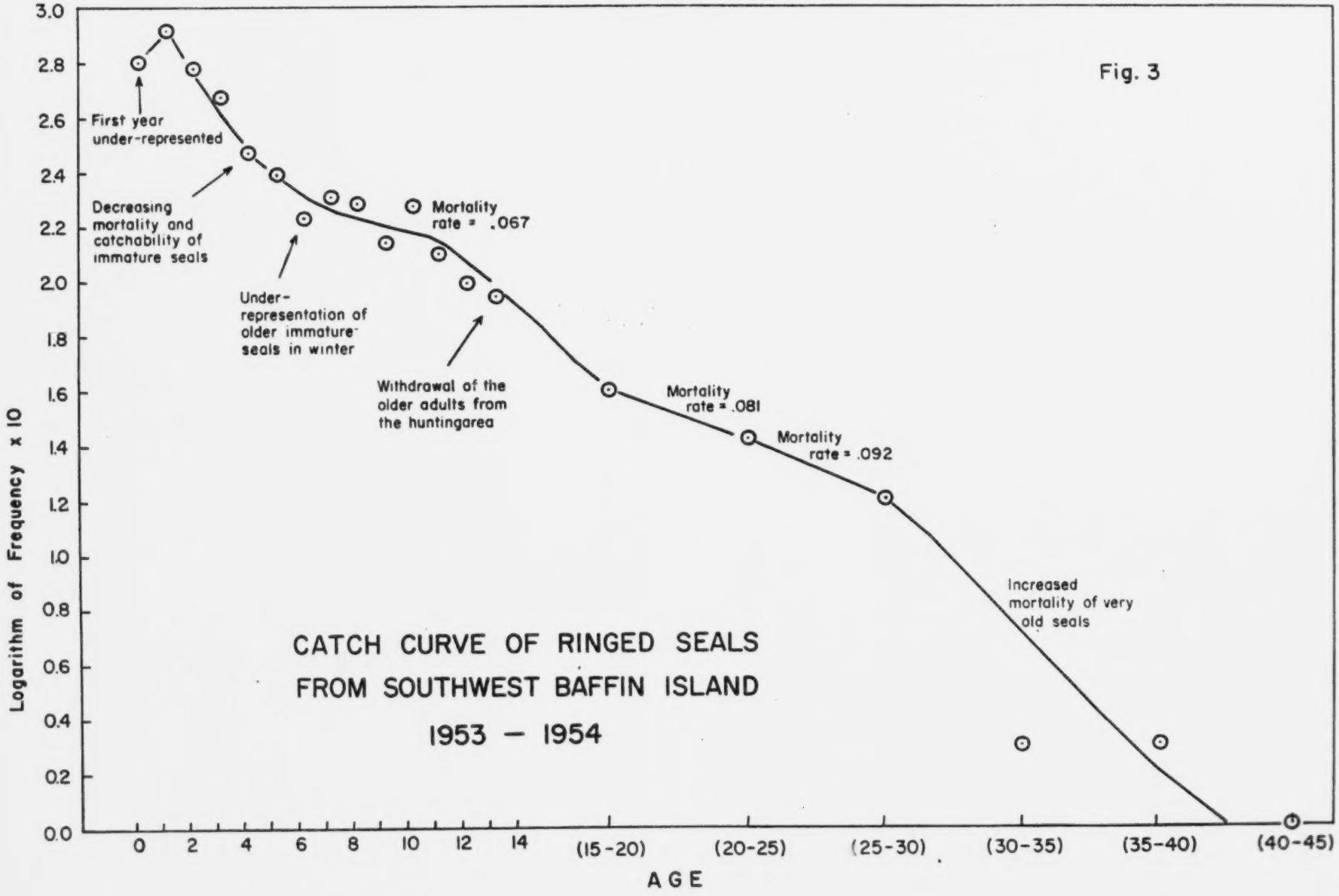
Fig. 3
First year under-represented
Decreasing mortality and catchability of immature seals
Under-representation of older immature seals in winter
Withdrawal of the older adults from the huntingarea
Mortality rate = .067
Mortality rate = .081
Mortality rate = .092
Increased mortality of very old seals
CATCH CURVE OF RINGED SEALS
FROM SOUTHWEST BAFFIN ISLAND
1953 – 1954
Logarithm of Frequency x 10
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
(15-20)
(20-25)
(25-30)
(30-35)
(35-40)
(40-45)
AGE

Table I. A balanced population of ringed seals in southern Baffin Island from which 7000 seals per year are removed by hunters.

Age	Number	Applied total mortality rate T=N + M - NM		Observed catch curve mortality rate (from selected catch curves)	Annual hunting kill (from combined catch curves)	Hunting mortality rate M= mort. / initial no.	Natural mortality rate N= T-M / 1-M	Per cent of females producing pups	Pup production
0	16,760	.31	progressively less catchable (summer kill)	not randomly sampled	1,290	.08	.25		
1	11,564	.30		.35	1,364	.12	.20		
2	8,094	.22		.25	914	.11	.12		
3	6,313	.15		.18	587	.09	.08		
4	5,366	.12		.15	425	.08	.04		
5	4,722	.10		.12	348	.06	.04		
6	4,250	.09		.09	254	.06	.03	.10	198
7	3,868	.09		.09	235	.06	.03	.50	899
8	3,520	.09		.09	220	.06	.03	.75	1228
9	3,203	.09		.09	205	.06	.03	.93	1340
10	2,915	.08	progressive withdrawal from hunting areas	-	178	.05	.03	.93	1220
11	2,652	.08		-	142	.05	.03	.93	1110
12	2,430	.07		-	116	.05	.03	.93	1017
13	2,235	.07		-	93	.04	.03	.93	935
14	2,079	.07		-	74	.04	.03	.93	870

Table I (continued) A balanced population of ringed seals in southern Baffin Island from which 7000 seals per year are removed by hunters.

Age	Number	Applied total mortality rate	Observed catch curve mortality rate	Annual hunting kill	Hunting mortality rate	Natural mortality rate	Per cent of females producing pups	Pup production
15	1,943	.07	-	63	.03	.04	.93	813
16	1,807	.07	-	53	.03	.04	.93	756
17	1,680	.08	.08	45	.03	.05	.93	703
18	1,546	.08	.08	41	.03	.05	.93	647
19	1,422	.08	.08	37	.03	.05	.93	595
20	1,327	.08	.08	34	.03	.05	.93	555
21	1,220	.08	.08	32	.03	.05	.93	511
22	1,122	.09	.09	30	.03	.06	.93	470
23	1,021	.09	.09	28	.03	.06	.93	427
24	929	.09	.09	26	.03	.06	.93	389
25	846	.09	.09	25	.03	.06	.93	354
26	770	.09	.09	23	.03	.06	.93	322
27	700	.10	-	21	.03	.07	.93	293
28	630	.12	-	18	.03	.09	.93	264
29	554	.15	-	16	.03	.12	.93	232

Table I (continued) A balanced population of ringed seals in southern Baffin Island from which 7000 seals per year are removed by hunters.

Age	Number	Applied total mortality rate	Observed catch curve mortality rate	Annual hunting kill	Hunting mortality rate	Natural mortality rate	Per cent of females producing pups	Pup production
30	470	.20	-	13	.03	.16	.93	197
31	376	.25	-	11	.03	.23	.90	157
32	282	.30	-	9	.03	.28	.80	105
33	197	.35	-	8	.03	.33	.70	64
34	129	.40	-	5	.03	.38	.60	36
35	77	.45	-	4	.03	.43	.50	18
36	43	.50	-	4	.03	.48	.40	8
37	22	.55	-	3	.03	.54	.30	3
38	10	.60	-	3	.03	.59	.20	1
39	4	.65	-	2	.03	.64	.10	0
40	2	.70	-	1	.03	.69	.0	0
Total	99,100			7,000				16,717

In the two columns of Table I dealing with pup production, it is assumed that each age group is 46.5 per cent female (sex ratio of immature, unsegregated seals). The reproductive rates of younger adult females are taken from McLaren (1958b). Among 42 older adult female seals from many areas, only 3 (about 7 per cent) were not pregnant in season. Thus a high annual production (total adult population x 0.465 x 0.93) is suggested for these older seals. Only one tract from a female older than 30 years was examined; the animal was senile, and progressive senility of the few animals older than 30 years is implied in the Table.]

Some basic features of the Table are:

1. About 2/5 of the pup production is ultimately utilized by the hunters.

2. At the beginning of the seal year, with all pups alive, about 53 per cent of the population is immature. About 7 per cent of this initial population will be utilized. At the end of the seal year, about 50 per cent is immature and about 8.5 per cent of this population has been utilized.

3. Since population estimates are based on counts performed in late spring (see page 21), by which time many of the first-year seals are eliminated, a maximum sustained yield of about 8 per cent of such estimated populations may be assumed.

If the Table is in error because some of the assumptions required to produce a balanced population are inaccurate, then it is probable that it errs on the safe side from the standpoint of utilization. Other tables have been constructed using different assumptions about the natural mortality in the first year and about the proportionate effects of decreasing catchability and decreasing natural mortality of the immature seals; within the bounds of the known hunting mortalities and reproductive rates, sustained yields of up to about 11 per cent seem possible. The figure of 8 per cent will probably be completely safe to apply anywhere. Of course, in areas where the age composition of the catch differs markedly from that in southwest Baffin Island, the sustained yield will be different. Generally, the sustained yield will be increased with increased utilization of young seals and decreased when adults are killed in proportionately greater numbers.

The Bearded Seal

The harbour seal, being rare, may be excluded from consideration. The harp seal, which shows about the same potential as the ringed seal in maximum sustained yield, experiences far greater utilization outside the arctic on the ice fields of Newfoundland and the Gulf of St. Lawrence. No

consideration of maximum sustained yield need be entertained in a local, subsistence fishery for this species.

The bearded seal has offered neither a completely suitable aging method nor a sufficiently large series of specimens for analysis of maximum sustained yield. It probably has a somewhat lower natural mortality rate than the ringed seal, being faced with fewer ice problems. The female begins reproducing at about the same age as the ringed seal, but produces a pup only once every two years. This is a severe limitation, and it is probable that the species cannot stand the hunting pressure which may be applied to the ringed seal. A maximum sustained yield of about 5 per cent of the mid-year population is suggested as being wholly safe.

NUMBERS OF SEALS AND THEIR AVAILABILITY

Population Estimates Based on Summer Censuses

In 1951, efforts were made from M/V Calanus to develop an adequate technique for the censusing of seals from shipboard. This was of limited success, but the method is recorded here so that other arctic travellers might systematise their observations on numbers of seals seen from shipboard.

A census must be carried out on a flat-calm day, preferably when there is a bright, pearly overcast. The distance of visibility of an average seal's head may be determined by dropping a gallon paint can over the stern, and timing its disappearance in the ship's wake. A more direct method might be used in scattered ice, where if a seal dead ahead at the limit of visibility comes up close to an observable piece of ice, the time taken for the boat to reach the ice gives a good estimate of the limit of visibility. Only the former method has been attempted by the author; paint cans disappeared from view when from 0.19 to 0.33 nautical miles astern in various conditions of light and times of day.

After the observer has estimated the limit of visibility, he sits at the bow with an unobstructed view ahead and swings his line of sight constantly through 180 degrees from side to side. Since seals generally stay up for a reasonable period, the scanning should not be too rapid. All seal heads are noted and identified; and the time, initial position and distance and direction travelled should be recorded so that repeats might be later eliminated.

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The effect of duration of seal dives on census results.

O = position of ship at O minutes.

D = position of ship at O+D minutes.

L = limit of visibility.

DK = distance covered by ship during average seal's dive.

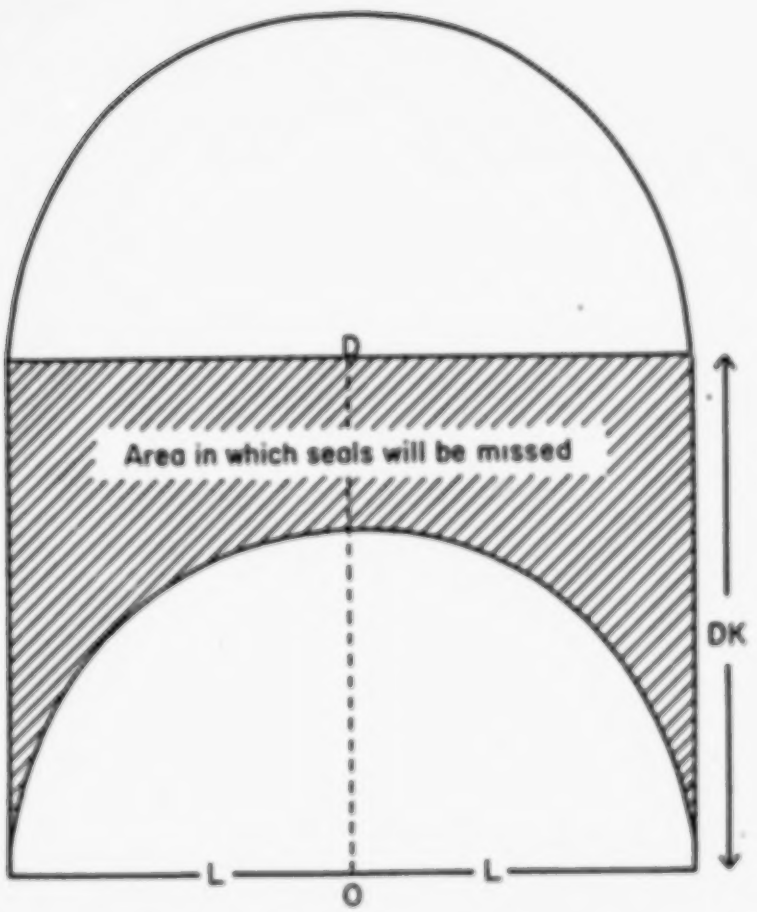

Fig.4

Since some seals will be under water, these will not be observed. The number missed will be dependent on the duration of the average seal's dive, as will be clear from reference to Figure 4. If we consider that all seals are moving randomly, which is equivalent in this case to their not changing position at all, then any seal which dives at time 0 minutes in the shaded area of Figure 4 beyond the limit of visibility at this time, will not be seen when it comes to the surface D minutes later. This reasoning applies to the whole census strip, and the formula for the theoretical number of seals (N_t) in the census area is:

(1) $$N_t = N_o \frac{(2L)(DK)}{\frac{\pi L^2}{2}}$$

Where N_o = the number of seals observed

L = the limit of visibility in nautical miles

D = the average duration of a seal's dive in minutes

K = the distance travelled in nautical miles per minute by the census boat

and the area censused (A) in square nautical miles is:

(2) $$A = MK(2L)$$

Where M = the duration of the census in minutes

The following illustrates the practical use of equations (1) and (2):

On the southwest side of Frobisher Bay running towards the head of the Bay and centered about 63° 05' W, 43 ringed seals were seen on August 15, 1951, in the period from 1015 to 1215 local time. The ship's speed was 6.9 knots (0.115 nautical miles per minute) and the limit of visibility 0.325 miles (a gallon can disappeared in 2 minutes and 50 seconds). From limited observations in southwest Baffin Island and Frobisher Bay, it appears that the average seal stays down while feeding for about 3 minutes.

Applying the above data in equation (1):

$$N_t = 43 \frac{(2 \times 0.325)(3 \times 0.115)}{\frac{\frac{22}{7}(0.325)^2}{2}}$$

= 58 seals

and,

$$A = (120)\ (0.115)\ (2 \times 0.325)$$

$$= 8.97 \text{ square miles.}$$

Thus this census implies about 6.5 ringed seals per square mile of water.

Similar censuses have been carried out in several other eastern arctic localities and it is believed that the method results in persistent and considerable underestimation, when the assumptions outlined above are used. As with big-game census from the air (Lumsden, 1958), many factors combine to limit the visibility. Thus it was only by keeping a very close watch on the diminishing tin can that it could be held in sight until almost 1/3 mile astern on the best of days. The sun's glare on one or other quadrant often limited observation, and ice, eyestrain, and fitful breezes were additional problems. Another possible source of error is the presumed average duration of dive, and a slight increase in this factor has a considerable effect on the census figures. MORE INFORMATION IS NEEDED ON LIMITS OF VISIBILITY AND DURATIONS OF DIVES OF SEALS.

Even though this census technique cannot give us an absolute measure of seal populations, it does offer useful comparative figures. Standard observations of this sort can give a fair indication of the relative numbers of seals on various coastlines and also the relative numbers of the different species, especially ringed and bearded, in each region.

Casual observations from shipboard on the numbers of seals seen in various arctic regions, such as have been made available to this office during the past few years, can give us very little information. A few censuses performed as described above would provide much more valuable data.

Population Estimates of Ringed Seals Based on Fast Ice Areas

The importance of fast ice has been discussed in the section on the essential biology of the species. In an underutilised population of ringed seals, the limiting factor on numbers appears to be the amount of fast ice tenable by the reproducing females. The most suitable ice is found in bays and fiords, among islands, and generally close to shore. It

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must be stable until late in the season, and it must be well snow-covered. Moreover it must offer sites for the construction of pupping lairs, generally in the drifts which form on inshore ice, over rough ice, or in the tented pressure ridges near shore. Thus in considering the amount of fast ice to be the limiting factor we imply that the limit is established by the number of suitable sites for lair construction, or that competition and territoriality may enforce an upper limit to the number of seals inhabiting a given patch of ice. It seems possible that suitable sites may be too few in some areas. For example, at Churchill, Manitoba, 2 seals were killed on February 24, 1954, in the open water at the floe edge of this shallow, unindented coast; both were adult females, one of 9 and the other 15 or more years. In the more suitable areas of Baffin Island and Foxe Basin, only one adult female (pregnant, at the end of March) has been taken in 128 seals of known age killed at the floe edge in late winter or spring.

In order to calculate a meaningful index of seal numbers based on the amount of fast ice along a coastline, we must first of all presume that equal areas of equivalent fast ice in different regions reflect the same seal numbers. Secondly, we must have figures for the numbers of seals represented by unit areas of fast ice of different qualities.

There are few references in the literature to accurate counts of seals on the ice, and most such records do not give the impression of great numbers. Thus, Manning (1943) saw no more than 15 seals on 12 square miles of fast ice on Hantzsch Bay, eastern Foxe Basin, but he pointed out that the ice there was relatively unsuitable for seals. Observations were terminated on May 26, before the maximum number of spring basking seals would have appeared. Wheeler (1953) counted 15 seals on 4.5 square miles of fast ice within Tessiuyak Bay, northern Labrador, on June 12, though earlier in the season, the seals were more common outside the bay. Pedersen (1930) found 52 breathing holes on a patch of ice 4 by 6 km. (6.9 sq. miles) in a small bay on the relatively exposed Liverpool Coast, near Scoresby Sound, East Greenland. This implies a maximum winter seal population of 7 per square mile, or about 13 seals per square mile when the offshore, unrepresented immature seals are included. Ellis (1957) saw 30 or 40 seals on fine days in early June from Button Point, in northeast Baffin Island. He has written (in litt.) that "the area of ice visible from Button Point when I was there was about 15 square miles. Apparently far more seals come onto the ice there in late June and July."

Tuck (1957) saw 40 seals along a single tide crack in the same general area. Freuchen (1915) wrote that there were hundreds on the ice at the mouth of Independence Fiord, northern Greenland, in mid June. McIntosh (1957, and in litt.) reported jar seals numbering into the eighties on 7 square miles of ice in Alexandra Fiord, Ellesmere Island. Finally, McLaren (1958b) reported 27 animals sunning on a large, detached piece of ice, ¾ square miles in area, in southwest Baffin Island on July 13.

Large differences in numbers of seals on the fast ice are expected locally and seasonally. In spring the numbers of seals hauled out varies with the weather, and also diurnally. The peak of numbers, depending on latitude, weather and locality, may occur from mid June to mid July, generally shortly before the break-up of the fast ice. The peak develops for two reasons: firstly, there is an increasing tendency for the winter residents to lie out in the waxing sun, and secondly, large numbers of immature seals, having wintered in the open water, move into the fast ice via leads, fissures and holes generated by the thaw. These facts mean that only the peak counts can be representative of the population as a whole.

In order to illustrate this seasonal trend in numbers, a series of observations was made in 1957 on the ice of Ney Harbour, Frobisher Bay. From the head of this short, narrow fiord, about 3.6 square nautical miles of ice can be seen. The counts outlined in Table II show that there was a gradual increase to about 35 seals per square mile in late June, after which numbers fell until break-up of the ice. It is probable that by no means <u>all</u> the population was on the ice when the peak count was made, but it is better at this stage to err on the safe side. The Table, in showing seasonal trends, might also be used to correct counts performed elsewhere. For example, if we presume the same time of peak numbers for Manning's (1943) count of 1.25 seals per square mile of ice on Hantzsch Bay, we might expect a count of 5 or 6 per square mile to be made there in late June.

It may be assumed therefore that each square mile of fast ice equivalent to that in Ney Harbour actually represents 35 seals, but the figure must be limited to only a portion of the ice which forms off arctic shores. There are two reasons for this. First, the Ney Harbour count is extracted from ice of superior quality for pup production, with a full complement of adults. Ellis (1957) has pointed out that seal breathing holes "generally occurred within a mile or so of shore in Admiralty Inlet, but they were scattered throughout the narrower Adam Sound". This pattern was related to the distance from shore, but had no correlation with depth. The ice inhabited by numbers of seals, then, does not extend very far offshore.

Table II. Counts of ringed seals on 3.6 square miles of fast ice on Ney Harbour, Frobisher Bay. All counts were carried out on sunny mornings, unless noted otherwise.

Date	Number	Number per square mile	Comment
1957			
June 1	31	8.6	overcast
June 11	19	5.3	
June 14	71	19.7	
June 18	74	20.6	early a.m.
June 18	81	22.6	early p.m.
June 19	93	25.8	
June 22	82	22.8	
June 24	115	31.9	
June 24	123	34.2	from higher hill
June 30	53	14.7	dull and foggy
July 2	86	23.9	first sun for some days
July 3	109	30.3	
July 4	74	20.6	deep melt-water pools on ice
July 8	30	8.3	break-up around rivers
July 14	0	0	break-up

The second limitation to the use of the figure of 35 seals per square mile for all fast ice is that, by the time the seasonal peak of basking occurs, much of the unstable, offshore fast ice has been broken off and converted to pack ice, giving up its seals to the ice remaining attached to shore. For these reasons it has been assumed that only ice within one mile of shore reflects a population of 35 seals to the square mile.

There is a class of ice which is less than one mile from shore, but which probably does not support as high a population. Fast ice quite close to shore on open coasts (much of the Hudson Strait coast of Quebec), or at the periphery of more complex coasts (around the outermost skerries of southwest Baffin Island), or around isolated islands in the open sea (King George and Sleeper Islands of Hudson Bay) are examples of this second-class ice. Ellis' (1957) count in early June of about 2.5 seals per square mile off the open coast of Button Point, Bylot Island, might be multiplied by 4 to give a peak count of about 10 per square mile of such ice.

For ice greater than one mile offshore, which forms a large percentage of the fast ice in most areas, we may presume a figure of 5 seals per square mile. This is perhaps equivalent to the peak count expected on the poor ice of Hantzsch Bay (Manning, 1943).

These figures are, of course, based on very small samples. It is hoped that readers of this paper will, when the opportunity is presented, perform the suggested counts of seals in as many areas of the arctic as possible, for this will enable a firmer basis for this population estimate to be established.

The extent of fast ice has been worked out on the 8-mile-to-1-inch maps of the National Topographic Series of the eastern Canadian arctic. Some references to the development of fast ice have been extracted from such sources as Hare and Montgomery (1949), Jenness (1953), Dunbar and Greenaway (1956), and Kaminsky (1954), but fast ice limits can be imputed to a map quite easily. Generally, ice will not extend much beyond the outermost capes and skerries. Where there is extensive formation beyond such limits, as in the larger channels of the high arctic islands and off northeast Baffin Island, the ice is almost certainly too ill-covered and unstable for use by reproducing seals. Using these criteria,

ice areas have been measured planimetrically in much of the eastern arctic. The region concerned is outlined in Figure 5. The measurements have been limited to this region, with some of which the author is familiar, owing to complications in other regions which have not yet been resolved.

On the Labrador coast, fast ice appears late and departs early, and probably reflects a small population per unit area. Seals may be locally abundant in James Bay, but the shortness of the winter season may limit the suitability of ice there. On these continental coasts, river inflow in spring may render inshore ice less suitable. In parts of the western and most of the high arctic, large areas are completely locked in fast ice in winter, and much of this is probably poorly covered with snow. The adults may prefer to winter in the bays, as in the eastern arctic, but the immature seals will have no open water in which to reside. There is a strong suggestion that the young seals migrate along the mainland coast of the western arctic, for a sample taken in September 1956 from Herschel Island, near the Canadian-Alaskan border, is composed almost entirely of first-year and second-year animals.

Table III lists the amounts of fast ice in the three main categories and the corresponding seal populations. It is apparent that the most complex coasts, offering the most fast ice near shore, produce the largest populations of seals, and have therefore the highest sustainable yields. The Table gives numerical expression to the facts which are familiar to many northern residents; for example, that the coasts of Baffin Island are generally good for seals, that Ungava Bay and much of Hudson Bay are second rate, and that the Hudson Strait coast of Quebec near Sugluk is a "hungry place". The figures also confirm the opinion of the widely travelled Peter Freuchen (1935) that fiord seals in southwest Baffin Island were more numerous than in any other arctic locality which he had visited.

Availability of Ringed Seals

The number of seals inhabiting a coastline determines the maximum sustained yield, but it does not necessarily reflect their availability to the hunter.

Summer availability index. In order to compare different coastlines, a simple index of availability can be derived for each area by dividing the seal population by the area of water within 10 miles of shore. This outer limit is selected since the ringed seal is essentially a coastal species, dispersing along shores from regions of high to regions of low

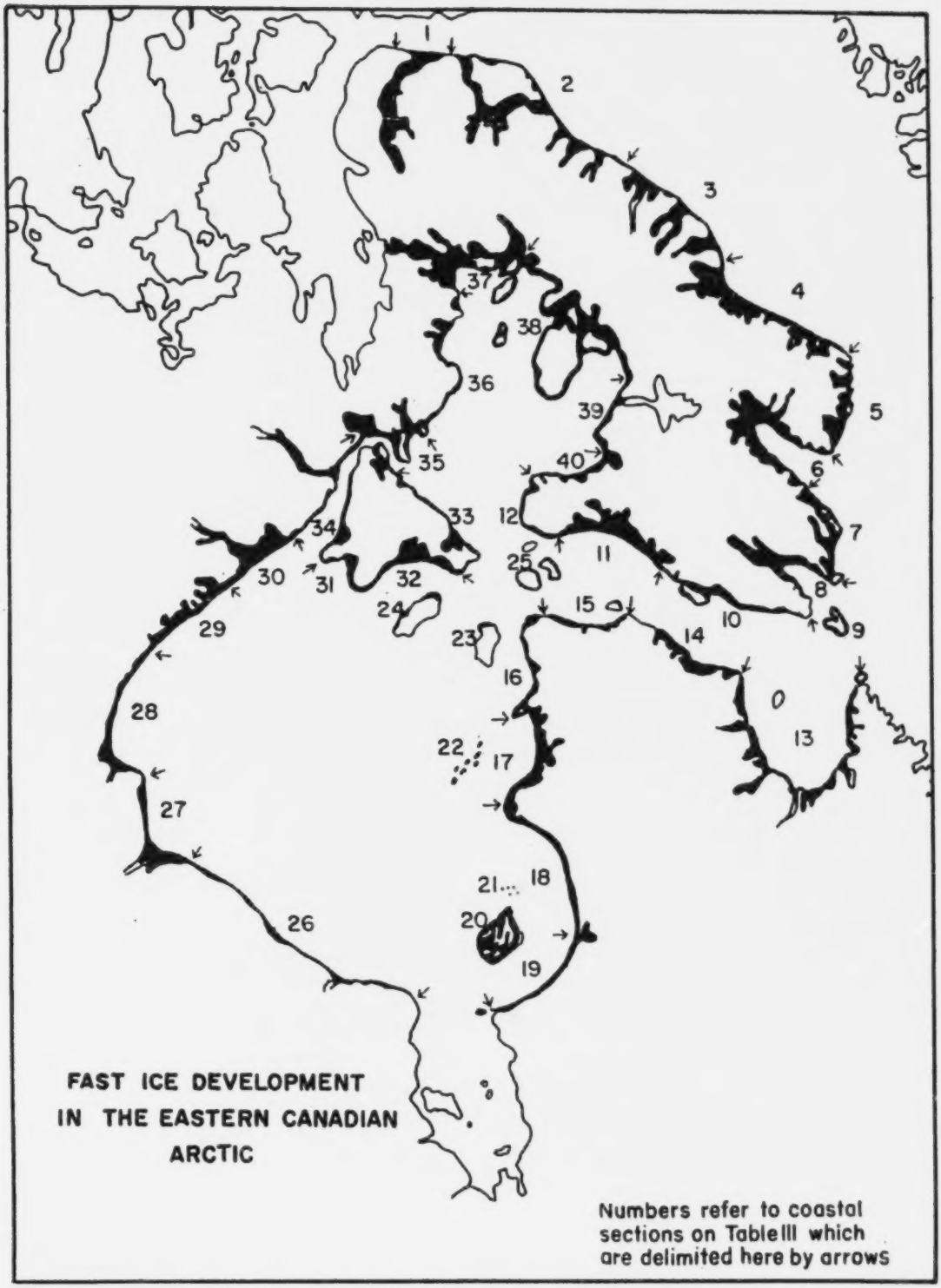

Fig. 5

Fast ice development in the eastern Canadian arctic.

seal productivity, but never moving very far offshore. Moreover, the limit also represents the maximum distance which an Eskimo is likely to travel offshore in pursuit of his quarry. The calculated values of the indices are presented in Table III, and a few points with regard to their interpretation are listed below:

1. Whereas the absolute population figures depend on the accuracy of very local counts, the availability index presumes only that fast ice within one mile of shore is overwhelmingly important, and that equivalent populations are reflected by equivalent qualities and areas of fast ice. In other words, much of the arbitrariness of the figures of 35, 10, and 5 seals per square mile is avoided.

2. In general, the differences between availability indices are less pronounced than differences between the corresponding population estimates. This is because there is more water within 10 miles of shore on the more complex coasts. For example, on two almost equal lengths of Hudson Bay coast (Cape Wolstenholme to Cape Smith, and Cape Smith to Portland Promontory) the population estimates are in ratio of about 1:3, whereas the availability indices have a ratio of about 1:2.

3. Given the same coastal complexity and populations, large concave coastlines such as Ungava Bay and Cumberland Sound have higher indices than straight or convex coastlines of the same length.

4. Islands have smaller indices of availability than their population estimates might imply since there is water on all sides. Thus, the Belcher Islands, which cover about 80 miles from north to south, have about twice as many seals as the nearby 190 miles of mainland coast between Portland Promontory and Richmond Gulf, but the availability indices of these areas are about the same.

In the section on the technique of censusing seals from shipboard (see p. 17), it was suggested that the numbers of seals per square mile derived from this method were consistently too low, but that such censuses might be taken to reflect the relative numbers of seals on different coastlines. In Table IV the summer indices based on fast ice considerations are compared with summer indices derived from shipboard censuses. The indices from the two sources are made equivalent by weighting for the number of square miles censused, the formula being:

Table III. Amounts of fast ice, populations, sustainable yields, and arctic. The coastal sections are delimited on Figure 5.

Locality	Good fast ice, less than 1 mile off shore (35/sq.mi.)	Exposed fast ice, less than 1 mile off shore (10 /sq.mi)	Poor fast ice, greater than 1 mile offshore (5/sq.mi.)
1. Admiralty Inlet, Cape Crawford to Cape Charles York	959	51	1,961
2. Northeast Baffin Island, Navy Board Inlet to Cape Adair (excl. outer Bylot Island)	1,526	35	2,542
3. East Baffin Island, Cape Adair to Cape Henry Kater	945	90	983
4. East Baffin Island, Home Bay area, Cape Henry Kater to Cape Dyer	1,931	49	1,358
5. East Baffin Island, Cape Dyer to Leopold Island	752		395
6. Cumberland Sound, Leopold Island to Hall Island	1,806		875
7. East Baffin Island, Hall Island to North Foreland on Loksland	984	10	657
8. Frobisher Bay, North Foreland to East Bluff	1,342		1,143
9. Resolution and Lower Savage Islands	215	53	43
10. Southeast Baffin Island, East Bluff to Fair Ness	628	175	98
11. Southwest Baffin Island, Fair Ness to Sakkiak Island	1,691	26	320
12. West Foxe Peninsula, Sakkiak Island to Cape Dorchester	221	74	32
13. Ungava Bay, Button Islands to Cape Hope's Advance	1,339	146	1,006
14. South coast of Hudson Strait, Cape Hope's Advance to Cape Weggs	534	16	315

vailabilities of ringed seals on coastal sections of the eastern Canadian

rea of ater less han 10 mi. ffshore	Area of water less than 10 mi. off floe-edge	Number of seals based on fast ice area (nearest 100)	Maximum Sustainable Yield at 8% utilization (nearest 10)	Summer Availability Index	Winter Availability Index
3,606	810	43,900	3,510	12.2	7.3
5,402	1,462	66,300	5,300	12.3	9.2
3,205	1,860	38,900	3,110	12.1	6.8
5,060	2,170	74,900	5,990	14.8	10.6
2,248	1,265	28,400	2,270	12.6	9.0
4,613	2,105	68,600	5,490	14.1	10.9
2,962	1,590	37,800	3,020	12.8	8.0
3,599	1,255	52,700	4,210	14.6	10.3
1,734	1,650	8,200	660	4.7	2.0
3,020	2,165	22,700	1,820	7.3	4.2
3,350	1,385	61,000	4,880	18.2	14.5
1,455	1,335	7,900	640	5.4	2.3
5,832	3,520	53,400	4,350	9.3	5.8
2,475	1,690	20,400	1,630	8.2	4.8

Table III. (Cont'd)

Locality	Good fast ice, less than 1 mile off shore (35/sq.mi.)	Exposed fast ice, less than 1 mile off shore (10 /sq.mi.)	Poor fast ice, greater than 1 mile offshore (5/sq.mi.)
15. South coast Hudson Strait Cape Weggs to Cape Wolstenholme & Charles Island	114	67	63
16. East coast Hudson Bay, Cape Wolstenholme to Cape Smith	213	44	200
17. East coast of Hudson Bay, Cape Smith to Portland Promontory	631	53	678
18. East coast of Hudson Bay, Portland Promontory to Richmond Gulf	685	121	187
19. East coast of Hudson Bay, Richmond Gulf to Cape Jones	305	87	180
20. The Belcher Islands	1,205	153	1,243
21. King George and Sleeper Islands	32	125	91
22. Ottawa Islands	104	166	63
23. Mansel Island	16	88	24
24. Coats Island	19	69	88
25. Salisbury, Nottingham and Mills Islands	75	67	11
26. West Coast of Hudson Bay, Cape Henrietta Maria to Cape Tatnam	34	105	386
27. West coast Hudson Bay, Cape Tatnam to Cape Churchill	4	8	437
28. West coast of Hudson Bay, Cape Churchill to Eskimo Point	27	5	329
29. West coast Hudson Bay, Eskimo Point to Baker Foreland	609	74	540

rea of ater less han 10 mi. ffshore	Area of water less than 10 mi. off floe-edge	Number of seals based on fast ice area (nearest 100)	Maximum Sustainable Yield at 8% utilization (nearest 10)	Summer Availability Index	Winter Availability Index
1,897	1,025	5,000	400	2.6	1.9
1,732	1,450	8,900	710	5.1	2.4
2,573	1,480	26,000	2,080	10.1	6.6
2,706	1,860	26,100	2,090	9.7	5.6
2,053	1,505	12,400	1,000	6.1	3.3
5,218	3,085	49,900	4,000	9.6	6.1
2,732	2,490	2,800	230	1.0	.4
2,269	2,120	5,600	450	2.5	1.0
1,689	1,600	1,600	125	0.9	.4
2,079	1,980	1,800	140	0.9	.4
2,725	2,570	3,400	270	1.2	.4
3,477	3,250	4,200	330	1.2	.5
1,503	1,480	2,400	190	1.6	.6
1,754	1,730	2,600	210	1.5	.6
2,615	1,810	25,000	1,980	9.5	5.2

Table III. (Cont'd)

Locality	Good fast ice, less than 1 mile off shore (35/sq.mi.)	Exposed fast ice, less than 1 mile off shore (10 /sq.mi.)	Poor fast ice, greater than 1 mile offshore (5/sq.mi.)
30. West coast Hudson Bay, Baker foreland to Cape Fullerton	537	20	172
31. Southampton Island, Bay of God's Mercy	—	70	116
32. Southampton Island, South Bay, Cape Low to Leyson Point	90	106	624
33. Southampton Island, East coast, Leyson Point to Cape Welmsford	210	30	394
34. Roe's Welcome Sound, both sides, Capes Fullerton & Kendall to Cape Munn and Beach Point	131	182	209
35. Repulse, Duke of York Bays, Frozen Strait and Lyon Inlet, Beach Point to Cape Fisher	771	23	1,237
36. East Melville Peninsula, Cape Fisher, Winter Island, to Arlagnuk Point	183	85	292
37. Northern Foxe Basin, Arlagnuk Point to Cape Jensen and west in Fury & Hecla Strait to 85° 30' W.	1,008	18	2,384
38. Northern Foxe Basin, Spicer Rowley, Koch, Prince Charles Islands and east coast from Cape Jensen to Taverner Bay.	498	60	2,800
39. East coast of Foxe Basin, Taverner Bay to Bowman Bay	—	—	260
40. North coast of Foxe Peninsula, Bowman Bay to Cape Dorchester	201	48	272

Area of water less than 10 mi. offshore	Area of water less than 10 mi. off floe-edge	Number of seals based on fast ice area (nearest 100)	Maximum Sustainable Yield at 8% utilization (nearest 10)	Summer Availability Index	Winter Availability Index
1,910	1,200	19,900	1,590	10.4	6.3
831	790	1,300	100	1.5	.6
1,698	1,960	7,300	590	4.3	1.9
2,328	1,290	9,600	770	4.1	2.1
2,953	2,550	7,500	600	2.5	1.1
3,430	1,450	39,900	3,190	11.6	8.9
2,480	2,150	8,700	700	3.5	1.6
4,045	710	47,400	3,790	11.7	13.8
9,761	6,560	32,000	2,560	3.3	1.8
1,070	1,060	1,300	100	1.2	.9
1,482	1,010	8,900	710	6.0	3.5

(3) $$I_c = N_t \frac{\sum(I_f \times A)}{\sum(N_t \times A)}$$

Where I_c = the index based on summer census

I_f = the index based on fast ice

N_t = the number of seals in summer census (page 19)

A = the area of water sampled in each region

For Table IV, $I_c = N_t \frac{2659.1}{924.4} = N_t \frac{}{7045.1}$ (2.88)

The agreement between the two indices is perhaps all it should be, considering the small areas which have been sampled by summer census. Also, as implied in the last column of comments, some of the censuses were performed in areas where the full population would not have been represented. Some of the local variations in index of availability will be discussed later.

Floe edge index. In the winter the seals available to the hunter at the open water of the floe edge are exclusively immature. We might expect that about half the seals inhabiting a coast are immature, and that a suitable index could be derived by dividing half the population by the amount of water within, say, 10 miles of the floe edge. There are two sources of error in this assumption: (1) not all immature seals are inclined to live in the open water in winter, and (2) a portion of the immature population is trapped in the bays at freeze-up. With more empirical data, it should be possible to analyse the representation of immature seals at the floe edge with some accuracy. Two methods of estimating the floe edge index are available to us at present: an accurate method[1] will be described in the following paragraph and a simplified version will be used to derive the floe edge indices listed in Table III. The whole section need only concern those readers interested in detailed mathematical treatment.

[1] I am indebted to Dr. John Stanley, Chairman of the Department of Zoology, McGill University, for developing the method and formulae for this purpose.

Table IV. Comparison of summer indices of availability based on fast ice, and summer census figures.

Area	No. of square miles sampled in censuses (A)	Number of seals per square mile (N_s)	Summer availability index from fast ice (from Table III) (I_f)	Availability index derived from summer censuses (I_c)	Comment
Frobisher Bay	39.1	5.4	14.6	15.6	
Cumberland Sound	5.9	3.1	14.1	8.9	Well offshore in centre of sound, seals scarcer
South coast, Baffin Island, near Lake Harbour	4.1	1.9	7.3	5.5	
South coast, Hudson Strait, near Wakeham Bay.	4.6	2.9	8.2	8.4	
South coast Hudson Strait near Sugluk	1.8	0.6	3.6	1.7	
South end Roe's Welcome Sound (en route Chesterfield to Southampton Island)	4.5	0.9	4.8*	2.6	Well offshore, seals probably scarcer
South Bay, Southampton Island	3.3	2.4	4.1	6.9	
About 35 miles north of Churchill, Manitoba	2.3	1.0	1.5	2.9	

* From combined indices of areas 30, 31, 34 of Table III, weighted for relative areas on which indices are based.

[We can presume that there are two factors responsible for trapping "unwilling" immature seals under the fast ice in winter: (1) the distance through water or under newly formed fast ice which a seal must travel in order to escape to the area of open water, and (2) the complexity of the escape route, which may be expressed in a number of ways, but perhaps most simply as the degree of deviation from a straight line which a seal must undergo to escape from its freeze-up position to the open sea.

In developing the formula, the following symbols are used:

h is a subscript pertaining to the open water hunting area.

b is a subscript pertaining to the fast ice breeding area.

N_h = the number of seals escaping to the winter hunting area.

k = the proportion of seals which choose not to attempt to flee the impending fast ice.

A_b = an area of water or fast ice from which the seals will attempt to emigrate before or at freeze-up.

N_b = the number of immature seals per unit area of water in this breeding area.

D_b = the distance of this breeding area from the open water of winter.

D_{min} = the greatest distance of travel which will offer no impedence to a seal, i.e., which will prevent no seals from reaching the winter open water.

D_{max} = the least distance of travel which will prevent all seals from reaching the open water of winter.

T_b = the total number of degrees of turn, both right and left, necessary in order to leave the breeding area and get to the open water of winter.

T_{max} = the greatest amount of turn which will impede no seals.

$T_{\frac{min}{max}}$ = the least amount of turn which will impede all seals.

n = the number of breeding areas under consideration.

To begin with, we must consider the effect of distance of the seal from the winter open water (D_b). We may presume that if $D_b \leqq D_{min}$, then there is no restriction on migration due to distance, and if $D_b \geqq D_{max}$, then the difficulty is so great that none of the would-be migrants reaches the open water of winter. For distances in between we assume that the difficulty is linearly proportional; this procedure obviates the necessity of expressing the probability of escape from the fast ice as a sigmoid curve in terms of D_b.

Let P_D = the proportion of seals which begin a journey from a distance D and reach the winter open water.

Then, under the above assumptions, the effect of distance will be:

(4) $$P_D = \frac{(D_{max} - D_{min}) - (D_b - D_{min})}{(D_{max} - D_{min})}$$

remembering in making calculations that if $D_b < D_{min}$ then we use a value $D_b = D_{min}$, and if $D_b > D_{max}$, then we use a value $D_b = D_{max}$.

The same formulation applies to the effect of coast line complexity, expressed as the number of degrees through which a seal must turn in escaping the fast ice area.

Under these assumptions:

(5) $$N_h = (1-k) \sum_{b=1}^{b=n} {}_{A_b} N_b \left[\frac{(D_{max}-D_{min})-(D_b-D_{min})}{(D_{max}-D_{min})} \right] \left[\frac{(T_{max}-T_{min})-(T_b-T_{min})}{(T_{max}-T_{min})} \right]$$

It is believed that this formula will give an accurate assessment of the numbers of immature seals in the open water at the floe edge in winter. Unfortunately, data are too few at present to establish some of the parameters, for which substantial samples from the following areas and circumstances would be required:

1. Samples from various distances inshore on fiord coasts shortly before freeze-up and during winter. The T_b factor would thus be at a minimum and D_{min} and D_{max} might be established.

2. Comparable samples from the same distances inshore from the floe edge of a complex, island-fronted region and a relatively simple, fiord coast shortly before freeze-up and during winter. These would serve to distinguish the relative effects of D_b and T_b.

In the absence of an accurate assessment, we may use a simplified method of estimating the winter availability index at the floe edge.

We have some evidence for the number of seals disinclined to migrate. Thus the stimulus to reside in the fast ice apparently increases with approaching maturity at about 6 or 7 years, for older immature animals are not fully represented in the floe edge samples. Table V makes use of the differences between summer samples which are assumed to represent the true immature population, and the winter floe-edge samples which reveal the progressive under-representation of immature seals with increasing age. We must adjust the samples for mortality rates (from Table I) since they were taken at different times of year, and differential mortality rates have destroyed their comparability. We must also enter a theoretical first-year sample, since this age-group cannot be sampled randomly (for reasons explained on page 10). Then, considering all first-year seals to be inclined to migrate (100 per cent) and almost all the second-year seals (95 per cent), we have derived the relative representations of the immature age-groups. This method, of course, presumes that each age class is affected to the same extent in its migrations by the factors of distance and complexity; for example, that learning or familiarity with the "escape route" have no effect. The sums of the percentage non-migrant seals in each age class imply that about 20 per cent of all immature seals choose not to migrate from the fast ice areas with impending freeze-up, or that they actively choose to live under the fast ice.

We have but one sample of any size from the late winter fast ice: in southwest Baffin Island 63 adults and 25 immature seals were sampled in areas averaging 16 miles shorewards from the floe edge. The sample is not adjusted for differential mortality rates, but these may be balanced by the under-representation of adult females, as the latter are less available while attending their pups in the spring.

Table V. The differences in age composition of samples of immature seals in summer and at the floe edge in late winter. The figures are adjusted for mortality rates, and the proportions of seals migrating to the floe edge are derived by presuming that age-class 0 is 100 per cent migrant and age-class 1, 95 per cent migrant.

Age	Observed frequencies		Theoretical frequencies from straight line fitted to log frequencies (equated for age 1)		Total annual mortality rates (from Table III)	Theoretical populations at freeze-up		Per cent migrant
	late summer	late winter	late summer	late winter		Total (from summer, plus 2 months mortality)	Migrant (from winter, minus 6 months mortality with age 1, 95 per cent represented as standard)	
0	not random	not random	-	-	.35	52	52	100 theor.
1	73	20	35.4	35.4	.30	33.6	31.9	95 theor.
2	51	12	25.0	20.4	.22	24.1	17.6	73 derived
3	33	6	17.7	12.7	.15	17.3	10.6	61 "
4	25	4	12.8	7.8	.12	12.5	6.3	50 "
5	22	3	9.1	4.8	.10	8.9	3.9	44 "
Totals			100.0	81.1		148.4	122.3	$\frac{122.3}{148.4}$ = 82 per cent

We will ignore the effect of coastal complexity since this is probably a rather minor correction on the effect of distance from the floe edge.

It may be reasonably assumed that at freeze-up most of the young seals (½ the total population) are evenly distributed within 10 miles of shore in southwest Baffin Island (within 3020 square miles) and that all adults are evenly distributed within the areas which will become fast ice (i.e. within 2037 square miles). Then, in the inshore breeding areas there are:

$$\frac{\frac{1}{2} \times 61{,}000}{2037} = c\ 15 \quad \text{Adults / square mile}$$

$$\frac{\frac{1}{2} \times 61{,}000}{3020} = c\ 10 \quad \text{Immature seals / square mile}$$

This means that, for 60 adult seals inshore at freeze-up, there will be about 40 immature seals. The actual winter sample mentioned above contained 63 adult and 25 immature seals; we may assume, therefore, that about 24 immature seals out of the calculated number of 40 will have remained under the ice. Of these 40 seals, 12 (or 20 per cent of 60, the correction for k, the proportion of the immature population which lives in the fast ice by choice -- see above) will not have attempted to migrate. This means that 12 (24-12) of the 28 (40-12) seals attempting migration were unsuccessful.

At a distance of about 16 miles from the floe edge, then, about 40 per cent of all would-be migrants are trapped. If we now consider that D_{min} is 0 miles, that is that no seals will be trapped only if there is no fast ice, then D_{max} by extrapolation is 40 miles, and all seals more than 40 miles from the winter floe edge at freeze-up will be trapped against their "will".

A rapid and rough survey of this distance factor has been made for the coastlines dealt with in Table III. The distances from the floe edge of evenly scattered points in the fast ice have been measured, and formula (4) has been applied to each of these points. If $D_{min} = 0$ and $D_{max} = 40$, then the probability of migrant seals reaching the floe edge may be derived from the average of the probabilities of the evenly scattered points for each coastal section.

The percentages of trapped seals are as follows (the number in brackets referring to coastal sections in Table III):

Admiralty Inlet (1) 85

Pond Inlet (2) 70

Frobisher Bay, northwest Foxe Basin (8,37) . 60

Home Bay, Repulse Bay, northeast Foxe Basin (4, 35, 38) 40

East and southwest Baffin Island and Cumberland Sound (3, 5, 6, 7, 10) 35

Northwest Hudson Bay (30) 25

Ungava Bay, northeast Hudson Strait, South Bay of Southampton Island, Cape Smith to Portland Promontory, the Belcher Islands, Eskimo Point to Baker Foreland, east coast of Melville Peninsula (10, 13, 17, 20, 29, 32, 36) 15

Richmond Gulf to Cape Jones, east coast Southampton Island, Bowman Bay to Cape Dorchester (19, 33, 40) 8

All other coasts on Table III 5

From these figures and from certain data on Table III, the winter indices have been derived. The method is as follows:

We assume that immature seals are scattered randomly throughout the open water within 10 miles of shore at freeze-up, and in winter they move out from the fast ice when they wish to and when they can, into water less than 10 miles off the floe edge.

If P = the percentage of seals trapped (as above)

N = the total population of seals ($\frac{N}{2}$ are therefore immature)

A_t = the area of water within 10 miles of shore

A_h= the area of water within 10 miles of the ice edge

A_b= the area covered with fast ice in winter, then the index of availability at the floe edge is:

$$(6) \qquad \frac{\left(\frac{N}{2}\right)\left(\frac{A_t - A_b}{A_t}\right) + (1-P)\left[\left(\frac{N}{2}\right)\left(\frac{A_b}{A_t}\right) - .20\left(\frac{N}{2}\right)\right]}{A_h}$$

It is by no means certain that this index is valid, and much more evidence is needed on the distribution of young seals before freeze-up, here considered to be random within 10 miles of shore. Young seals are probably more concentrated off shore, but the formula is the best approximation that can be given at present.]

Fast ice index. The third general type of hunting is carried out on the fast ice in spring. Since we have already presumed that equivalent fast ice areas represent equivalent seal populations, it follows that the availability indices of seals on the fast ice will not vary geographically, provided hunting is carried out on comparable fast ice. It is indeed a fact that in areas of low seal availability, the most profitable hunting may be carried out on the spring ice when the population, both young and old, is concentrated in a relatively small area. Changes in the fast ice index will be primarily seasonal as seals become more available with the approach of break-up. Figure 6 which is based on the counts in Ney Harbour in 1957, and scattered observations at other latitudes, shows the order of change of index which will be found. It is only a very rough guide however, since the timing of the season may vary from year to year. The peak index for all coasts is assumed to be 10, and the variation of season with latitude, which corresponds roughly with the times of break-up, is indicated by the sloping lines.

Breathing hole and tide-rip indices. These two methods of hunting are much less commonly practised in the eastern Canadian arctic, and the associated indices of availability are difficult to assess. The numbers of adult seals wintering under the fast ice are assumed to be the same in unit areas of ice within one mile of shore whenever found, but the numbers of immature seals may vary with the distance from the floe edge. However, the indices of availability will only vary slightly, and much more will depend on the skill of the hunter in carrying out the more demanding methods of hunting seals at their breathing holes. Every tide-rip has its own peculiarities,

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Fast ice availability indices of seals, based on number of seals observed in Ney Harbour, Frobisher Bay.

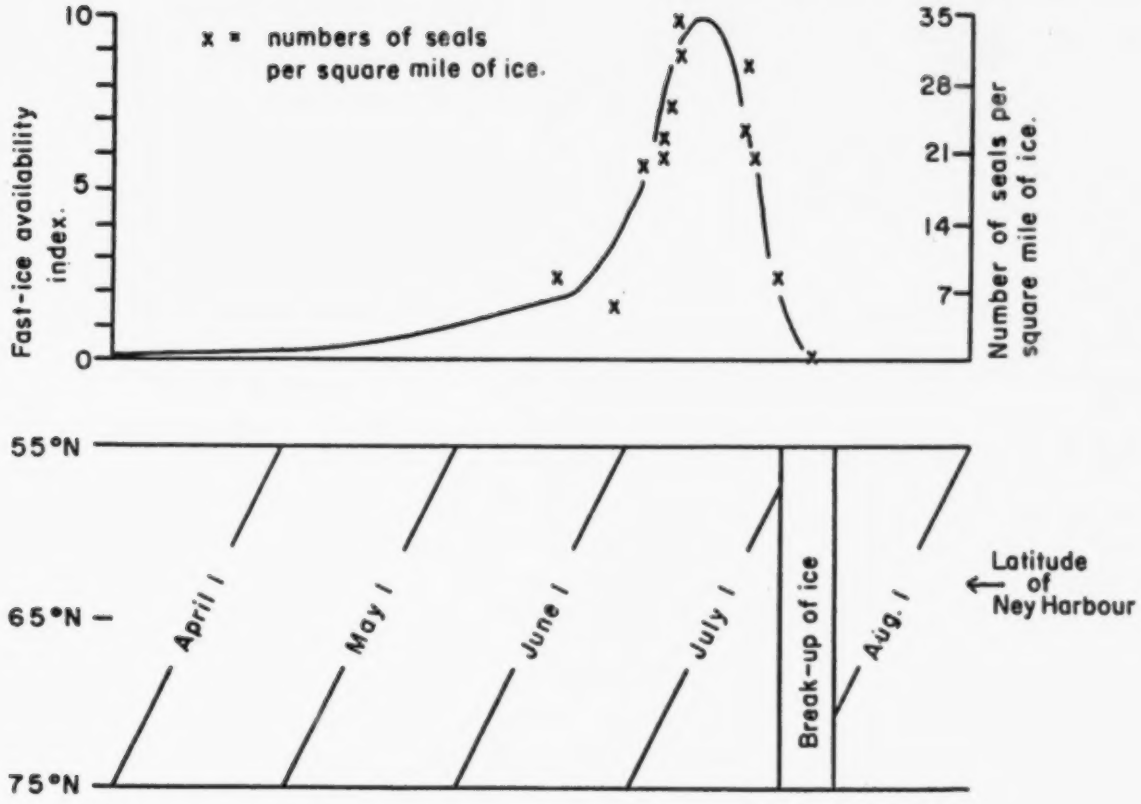


Fig. 6

and it is just as difficult to develop an index for this form of hunting, especially as excessive hunting may actually reduce the available seals in the confined area. However, figures for the catch per unit effort will be suggested for both these methods of hunting in the next section.

Catch of ringed seals per unit effort. The previous sections offer figures which reflect the relative abundance of seals in the water in summer and winter in much of the eastern arctic. These may be made more meaningful when converted into catch per unit effort, the index of actual hunting productivity.

We have accurate data on hunting trips chiefly from the summer. A proper evaluation of the hunting productivity from boats must include the following considerations:

1. The hunts must be carried out seriously; wild springtime indulgences, with excessive crowding on the boats, or hunting incidental to chartered journeys (too often witnessed by occasional travellers with the Eskimos and thought to be typical) cannot give a true picture.

2. Trips in which much time is spent in hunting the more valuable, harder-to-get bearded seal cannot be included.

3. The hunts must be of equivalent lengths of time.

4. They must be carried out in equivalent weather conditions.

5. The type of hunting craft must be considered.

6. Unfortunately, no account can be made of the hunter's abilities. If the above conditions are satisfied, we must presume that hunters are all equally skilful.

Table VI lists the results of 40 hunting trips carried out in ideal sealing weather. The data are summarized in the form of kills for each type of craft used and the averages are adjusted for a hypothetical coastline with an availability index of 10. The averages suggest that, from larger craft, about 0.1 seals per hunter per day per unit availability index may be killed, and about twice this from smaller boats.

The results of hunting carried out at the floe edge in spring may be considered in the same way. The analysis of 5 trips in southwest Baffin Island, 3 in Admiralty Inlet, and

Table VI. Numbers of ringed seals killed in summer in various arctic localities. The figures are based on hunting trips of about a day's duration in calm weather; seals lost by sinking are included.

Locality	Summer availability index (from Table III)	Dinghy or canoe with motor			Whaleboat or trap-boat with engine			Peterhead 'Schooner'		
		No. of hunts	Av. per boat	Av. per hunter	No. of hunts	Av. per boat	Av. per hunter	No. of hunts	Av. per boat	Av. per hunter
Southwest Baffin Island	18.2	3	6.33	3.17	6	6.00	2.00	8	10.50	2.10
Northwest Baffin Island	12.2				9	3.67	0.92			
Northwest Foxe Basin	11.7	3	2.67	2.67	4	5.00	1.67			
Ungava Bay	9.3							7	3.71	0.74
Weighted averages for availability index of 10			2.88	2.02		3.36	1.00		3.48	0.99

8 in Pond Inlet, show an average catch per unit effort of about 0.12 seals per hunter per day per unit floe edge availability index. This estimate is based on hunts carried out in March, April and May, and the figure would undoubtedly be much reduced in the height of winter. A figure of about half the springtime value (about .05 seals/hunter/day/unit availability index) is suggested for mid-winter conditions in more southerly areas.

A few figures are available on the productivity of hunting carried out on the spring ice. The results of 19 serious hunting trips on the spring ice of southwest Baffin Island, Frobisher Bay, Foxe Basin and northern Baffin Island, adjusted for season (see Fig. 6), suggest that about 0.63 seals might be taken per hunter per day per unit availability index at the peak of the basking season. Thus, from Figure 6, a hunter going out on to the fast ice of Frobisher Bay (latitude 63° N) in mid-May might be expected to average about 0.8 (0.63 x 1.25) seals for each day's effort; a month later he might secure 3.5 (0.63 x 5.5) seals during the day; at the peak of late June, about 6.3 seals will be his for the day's effort.

It might be objected that the kill does not necessarily vary directly with the density of seals on the ice, but observation suggests that the seals become increasingly indolent and easier to shoot as the season progresses.

For hunting through the ice at breathing holes, many factors of individual Eskimo ability have to be considered. Seals are hunted in this manner in the eastern arctic only in calm, dark, winter weather. On such ideal days perhaps 1.5 seals might be taken per hunter per day, judging from the few records of such hunting which we have for analysis. When the Eskimo is fortunate enough to dwell in a region of high tides and complex coastlines, he might secure an average of 2 seals per day in the tide rips which are to be found on such coasts. This figure is based on the results of a few hunts in southwest Baffin Island and Frobisher Bay involving one or two hunters at each tide-rip.

Table VII summarizes the basic catch per unit effort of hunters in various seasons and circumstances.

Local modifications of availability of ringed seals. The availability of ringed seals, expressed as catch per unit effort, is believed to reflect quite well the conditions of hunting in equivalent circumstances on the various coastlines, but there are local modifications which must be considered in order to complete the picture.

Table VII. Summary of catch per unit effort of ringed seals in good hunting conditions, by 'average' hunters.

1. Hunting from larger boats in summer	0.1 seals per hunter per day per unit summer availability index (use with Table III)
2. Hunting from smaller powered boats in summer	0.2 seals per hunter per day per unit summer availability index (use with Table III)
3. At floe edge in mid winter	0.05 seals per hunter per day per unit winter availability index in more southerly arctic. Almost nil in high arctic (Table III).
4. At floe edge in spring	0.12 seals per hunter per day per unit winter availability index (use with Table III)
5. At tide-rips	2 seals per day per hunter
6. Through holes in fast ice, by waiting	1.5 seals per day per hunter
7. On ice in spring	0.63 seals per day per hunter per unit availability index (use with Figure 6)
8. Boats launched at floe edge in spring	About 0.2 seals per hunter per day per unit floe edge availability index

1. Local breeding concentrations. Although ringed seals are inclined to wander somewhat, the adults, at least, tend to concentrate in the more suitable breeding areas. Large coastal sections are analysed as units in Table III, but within these sections there may be some variation in distribution of breeding seals. Thus, in the long, relatively unindented northeast coast of Hudson Strait (area 10 in Table III and Fig. 5), we might expect more seals to be concentrated in the somewhat complex area around the west end near Lake Harbour; similarly, between Cape Weggs and Cape Smith (areas 15 & 16) breeding seals are probably locally more abundant near Wolstenholme and the Digges Islands. A glance at suitable arctic maps will suggest more such concentrations.

2. The effect of dispersal. Ringed seals do not disperse very far offshore, but there appears to be a movement of young seals from regions of high productivity on complex coasts to nearby regions of low productivity. Thus the good hunting off Cape Dorset and Lake Harbour is probably a direct result of the great breeding area between these posts. This means that the availability indices of complex coasts are inclined to be reduced, while those of nearby simple coasts are raised a little. Where long stretches of coastline of more or less unvarying complexity are separated from others of different complexity by large reaches of open water, the effect of dispersal need not be considered. There is also some indication that current direction has a small effect on the dispersal of the young, offshore-dwelling seals.

Those areas which probably have somewhat greater indices of availability than are implied in the Tables are as follows:

Resolution and Lower Savage Islands (Coastal Section 9)
The Lake Harbour area, and, to a lesser extent, points east (10)
The coast to the west of Cape Dorset (12)
The area around Charles Island and somewhat to the west (15)
The area just north of Cape Smith (16)
The area just south of Eskimo Point, perhaps including Churchill (28)
The area some distance to the south of Arlagnuk Point (36)

Naturally, regions which contribute seals to those of lower productivity will have somewhat reduced indices of availability themselves. The adjacent regions contributing to the above listed areas may be easily seen on the map (Fig. 5).

3. Offshore and inshore concentrations. In summer seals are generally more common offshore; this applies particularly to the immature animals. If the movement out of inshore waters were the same on all coastlines, then the availability indices would not be affected; however, it seems that the summer concentrations of seals differ on various coastlines. Movement may be to some extent suppressed on complex coasts, which seem to harbour higher concentrations of both young and old seals in their inshore waters in summer. Such a condition appears also to apply to simple fiord coasts. This distribution is doubly advantageous to the hunter, for not only does he have a greater supply of seals, but he is able to hunt among generally more sheltered bays and islands, away from the offshore winds and swells.

4. Feeding concentrations. Although the ringed seal has a wide range of diet, and is certainly not limited by the availability of food species, it appears often to concentrate in regions where food is abundant in summer. Thus its predilection for floating ice in summer may be due to the food species which may be carried with it; for example, polar cod and certain amphipod crustaceans are known to associate with ice. Again, concentration of seals may be due to strong upwelling, such as is shown so remarkably in the area near Cape Dorset; certainly every seal taken there is crammed full of large Themisto, which may be brought near to the surface. In Frobisher Bay, on the other hand, seals appear to be most concentrated in summer in the belt of islands about half way down the bay and along the north side (see Fig. 7). This is a good breeding area, although the fiords, where seals are scarcer in summer, appear just as good or better. Perhaps the concentration of seals about the islands is connected with the strong tidal currents, upwelling, and general instability of the local waters as discussed by Dunbar (1958). Themisto and Thysanoessa, planktonic species which were rare in stomachs from seals in shallow, inshore waters in other areas of the arctic, were dominant in stomachs from seals killed among these Frobisher Bay islands in May, 1957.

5. Local hunting effects. Traders of very long experience at one post will often speak of depletion of numbers of seals in the post area over the years. Often the local scarcity of seals is attributed as much to the generally high local activity, particularly of motorboats, as to the effects of hunting pressure. In some regions the area affected is quite extensive, as for example the head of Frobisher Bay (see Figure 7). This has been attributed to the high degree of activity at the air base, though it seems that the area has never been very good for seal hunting at any time in the past. Perhaps appropriate to this discussion are the walrus which appear to have deserted the area of Thule, apparently because of the aircraft.

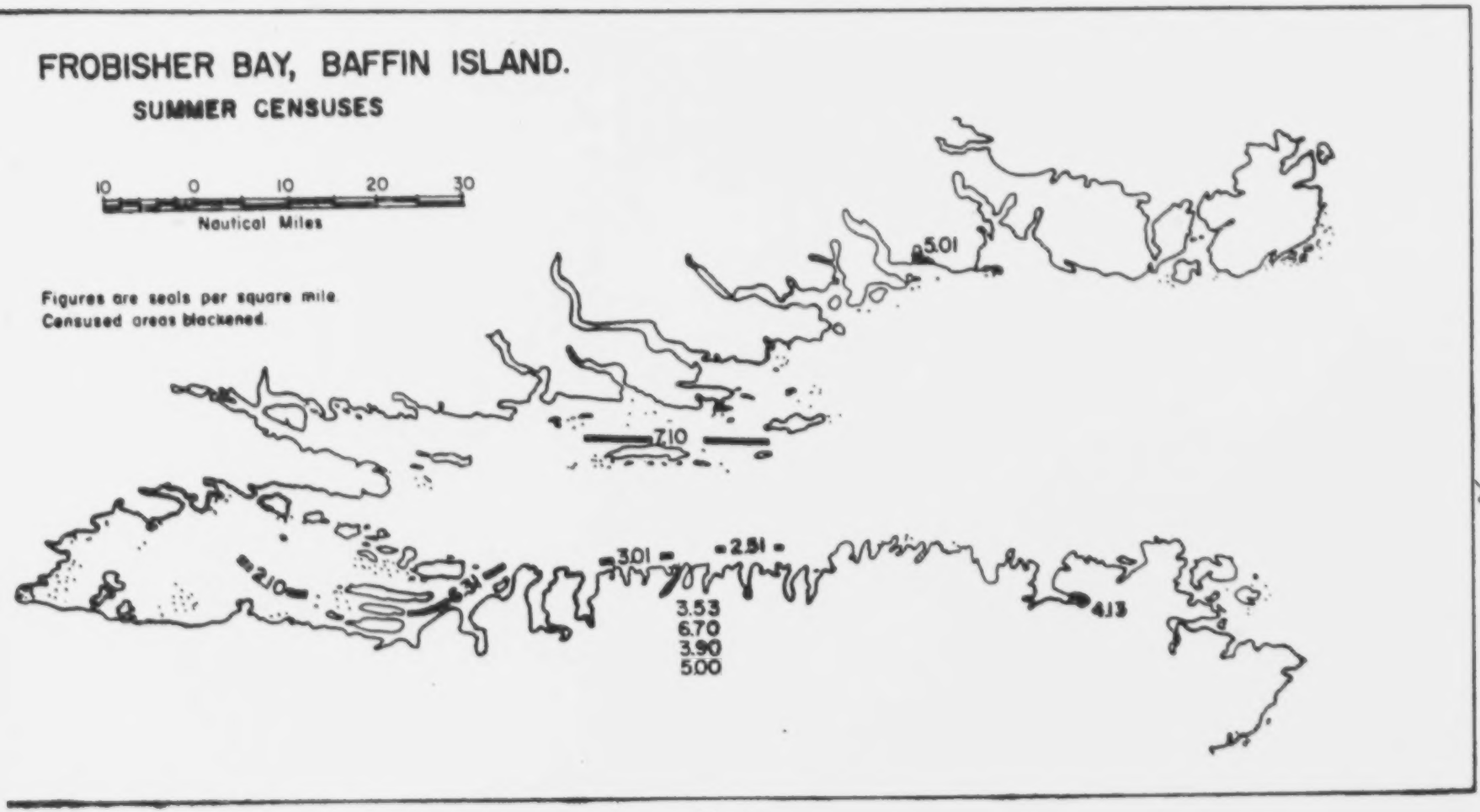


Fig. 7

Summer censuses in Frobisher Bay, Baffin Island.

Heavy local hunting will result in a steepening of the catch curve (see pp. 1-2); this has evidently occurred along the southwest coast of Foxe Peninsula, which depends upon the complex coasts to the east for replenishment of its younger seal stocks.

6. The effects of climate. Our figures on catch per unit effort are based on hunting carried out for a full day in ideal circumstances by hunters of average skill, but there are differences in the climate in the eastern Canadian arctic which certainly affect hunting conditions.

As a correction to the availability index of a coastline, it would be well worthwhile analysing the number of calm days, suitable for hunting, which might be expected in an average summer. As a general rule, high arctic areas have more days of calm weather in summer than areas in middle arctic latitudes. In the author's limited experience, the Frobisher Bay area offers many more days of relative calm than does northern Hudson Bay. It should also be noted that complex coasts, with their large seal populations and high indices of availability, offer more suitable conditions for the operation of small boats in their sheltered inshore waters. Probably the necessary data for an analysis of weather conditions are available in part in the records of the arctic weather stations. Rae (1951) has given the monthly average wind speed for several arctic weather stations, but unfortunately this is not the parameter which is needed in the present study.

Wind direction may be locally important and, in general, offshore winds are more suitable for the hunter; thus the Eskimos of southwest Baffin Island claim that ringed seals tend to move inshore during offshore winds to avoid the rougher waters. Wind direction may be especially important in winter, for hunting is generally unsuitable when the wind has brought the pack ice into the floe edge. Along the east coast of Hudson Bay the Eskimos are troubled by prevailing northwest winds in winter, and often have to travel out on the consolidated pack to hunt, while in northwest Hudson Bay the Eskimos benefit from the wide lead which is generally to be found along the floe edge.

In the southern arctic, Eskimos can hunt at the floe edge all the winter long with some discomfort. In the far north, hunting techniques are limited by the winter darkness, and the seals can only be caught through the ice at their breathing holes. This method also requires calm weather;

thus, during the two dark months in 1954-55 in Admiralty Inlet, only about half the days were suitable for such hunting (D. V. Ellis, personal communication).

Numbers and Availability of Bearded Seals

There is as yet no key to the distribution and abundance of the bearded seal comparable to that developed above for the ringed seal. It is possible that the bearded seal, unlike the ringed seal, is limited by the availability of its benthonic food. Vibe (1950) places a limit of depth of diving for food at 80 metres (44 fathoms). In the eastern Canadian arctic the bearded seal appears to be most common along those coastlines where suitably shallow water extends well out beyond the limit of winter fast ice; for example, Ungava Bay, Foxe Basin, and much of Hudson Bay. The bearded seal does not as a rule maintain breathing holes in the winter, and it is this inability to cope with fast ice which limits its numbers in the central and northern arctic of Canada. Perhaps some sort of indication of numbers of bearded seals might be derived by measuring the areas of open water in winter which are within the 80 metre line.

The only way at present to derive a first approximation of bearded seal numbers is by comparing the relative abundance of this species and the ringed seal. Table VIII gives a few such comparisons, based on censuses from restricted areas of the eastern Canadian arctic. Not much confidence can be attached to these figures, but they do suggest that Hudson Bay and Ungava Bay, with their shallow waters and relatively small development of fast ice, are more plentifully supplied with bearded seals. Table IX suggests populations of bearded seals throughout the eastern arctic. The availability indices are based on the few figures given in Table VIII, as well as on evidence from the catch statistics of the various regions. The populations are determined by multiplying the availability indices by the areas of water within 10 miles of shore (Table III), a most crude method, but the best available at the present time. The sustainable yields are 5 per cent of the populations (see p.17).

The populations and sustainable yields of more limited regions within the larger coastal sections listed on Table IX may be determined on a simple proportional basis by comparing the areas of water within 10 miles of shore.

Table VIII. Relative numbers of ringed and bearded seals observed in certain eastern arctic localities.

Area	Number of counts	Number ringed seals observed	Number bearded seals observed	Availability index of ringed seal (Table III)	Derived availability index of bearded seals
Southwest Baffin Island	3	111	5	18.2	0.8
Frobisher Bay	7	78	6	14.6	1.1
Wakeham Bay	1	11	2	8.2	1.5
South Bay, Southampton Island	2	11	3	4.3	1.2
Ungava Bay	*2 summers	3	1	9.3	3.1
South end of Roe's Welcome Sound	1	3	2	4.8**	3.2
Near Churchill, Manitoba	2	4	6	1.5	2.2

* From Dunbar (1949); the numbers expressed are a ratio only.

** Combined index of areas 30, 31, 34, Table III.

Table IX. Estimates of bearded seal populations, availability indices and sustainable yields in the eastern Canadian arctic.

Area	Equivalent areas on Table III	Availability index	Area of water less than 10 miles offshore (from Table III)	Population (nearest 100)	Sustainable yield (nearest 10)	Catch per boat per day
North and east coasts of Baffin Island	1 to 5	0.5	19,521	9,800	490	0.3
Cumberland Sound and Frobisher Bay	6 to 9	1.0	12,872	12,900	770	0.5
South coast Baffin Island	10 to 12	1.0	7,828	7,800	390	0.5
Ungava Bay	13	2.5	5,832	14,600	730	1.3
Hudson Strait coast of Quebec	14 to 15	1.5	4,372	6,600	330	0.8
East coast Hudson Bay (including Belchers and other Islands)	16 to 22	2.0	19,283	38,600	1,930	1.0
West coast Hudson Bay	26 to 30	2.0	11,259	22,500	1,130	1.0
Northern Hudson Bay (Southampton Island and Repulse Bay areas)	31 to 35	2.0	11,240	22,500	1,130	1.0
Islands of western Hudson Strait and northern Hudson Bay	23 to 25	2.0	6,493	13,000	650	1.0
Foxe Basin	35 to 40	2.0	18,838	37,700	1,880	1.0

From 13 sealing trips from whaleboat or Peterhead in southwest Baffin Island, we may very tentatively suggest that about 0.5 bearded seals may be taken per boat, per day, in this area (since the bearded seal is divided among crew members, per boat is the proper unit). From this figure the catches per unit effort listed in the last column of Table IX are easily derived. Of course, some of the same limitations of weather, season, etc., which affect the hunting of ringed seals, apply to hunting for bearded seals (see pp. 49-51), and obviously many more data will be required before really valid deductions can be drawn about the take of bearded seals.

PRODUCTS OF SEAL CARCASSES

In utilizing seal populations, it is not sufficient merely to consider numbers and availability, since there are many variables which affect the yield from seal carcasses.

The Relationship Between Length and Weight

Log-length to log-weight relationships have been established for about 75 ringed seals. These are set out with the straight line of best fit in Figure 8. Seals vary considerably in amount of blubber, and the straight line may be considered to represent ringed seals of average fatness in late summer. However, the length of a seal is often much easier to obtain than its weight, and in any commercial development of seal hunting, the native hunter could most easily be paid by length of seals caught.

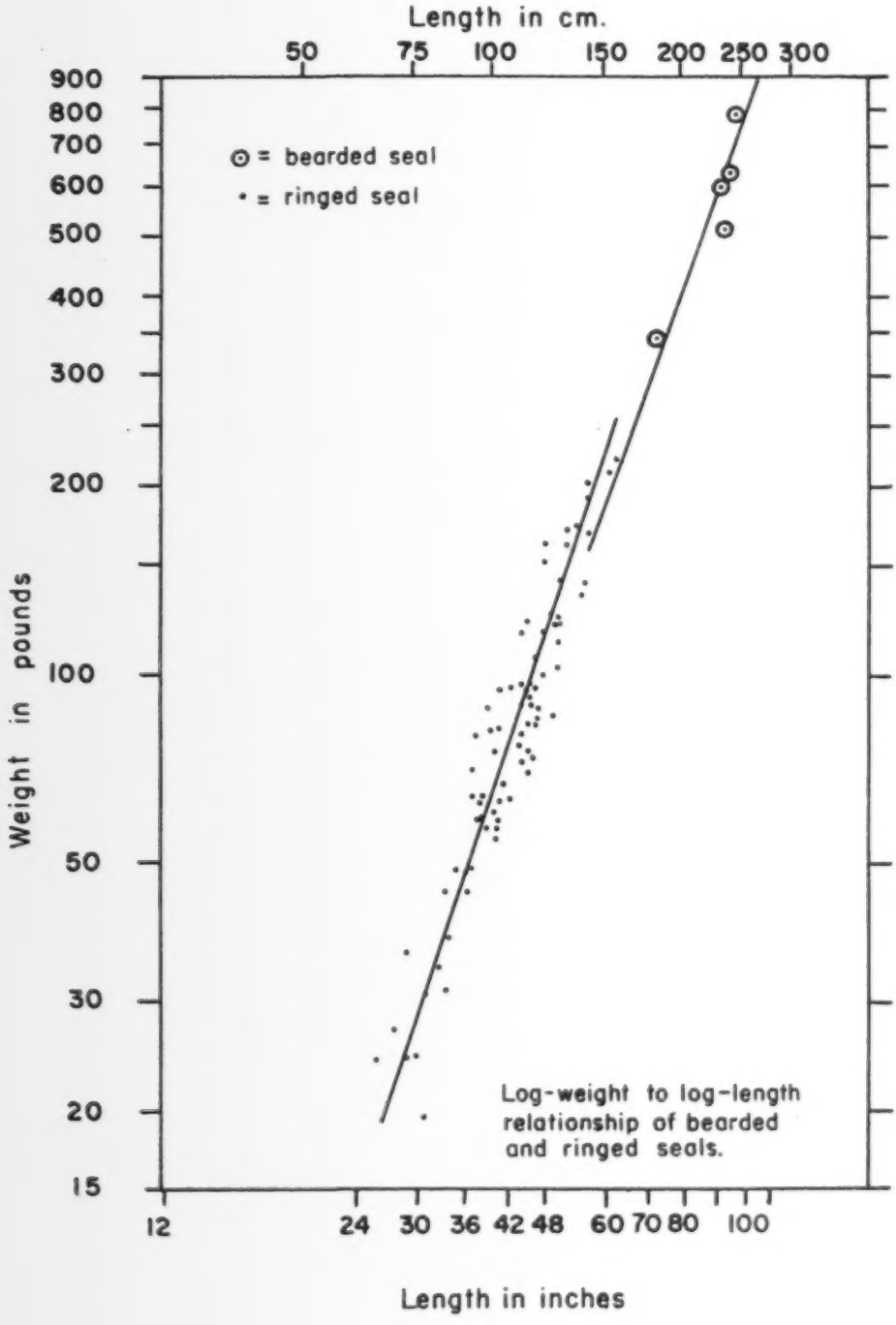
For the ringed seal:

(7) $$\log \text{weight in pounds} = 3.005 (\log \text{length in inches}) - 2.9882$$

The seal must be measured in a straight line, from tip of nose to end of tail, with the head in a relaxed position; this is best done by pulling the head out and letting it fall back into place.

Only a few observations are available on the relationship between weight and length of bearded seals. The few specimens in Figure 8 suggest that they weigh somewhat less than equivalent length ringed seals, probably due to the smaller blubber development and more elongate shape of the larger species. For the bearded seal, then:

Fig. 8



Log-weight to log-length relationship of bearded and ringed seals.

(8) log weight in pounds = 2.8519 (log length in inches) - 2.8023

For convenience, a series of weights and lengths of average ringed and bearded seals are set out in Table X.

Local, Seasonal and Geographical Variation in Size of Seals

Ringed seals of different localities and latitudes differ markedly in size. Weight varies as the cube of the length, and we cannot determine the average weight of a catch merely by working out the average length, therefore, since longer seals have a greater influence proportionately on the average weight; it is quite possible that two samples have the same average length but different average weights. Estimates of the average length and weight of seals in any area or circumstance may be worked out from the age-composition of the catch. The formula is:

(9) $$\frac{\sum fx}{\sum f}$$

where, x = the average length, or weight of an age-group

f = the frequency of seals in that age-group.

From samples of seals taken in southwest and northern Baffin Island, northern Hudson Bay, northern Foxe Basin, and the high arctic (illustrated by McLaren, 1958b) we have good evidence of the degree of variation in size with latitude. Variation with season is a matter of age segregation (also discussed on pp.10 and 38, and extensively by McLaren, 1958b) and can be accounted for in the above formula. Table XI gives lengths and weights of average seals (variation of blubber with season is not accounted for) in various geographic regions and seasons.

The average weight of a population, together with the local availability indices (Table III), give a more or less complete account of the suitability of a coastline for the hunting residents.

The bearded seal appears to show neither the geographical variation nor the local and seasonal age segregation found in the ringed seal. From 59 measured specimens, we may suggest an average length of about 81 inches and an average weight of 465 pounds for bearded seals caught anywhere in the eastern Canadian arctic.

Table X. Length-weight relationships of average ringed and bearded seals in late summer condition of fatness.

Ringed Seal		Bearded Seal	
Length (inches)	Weight (pounds)	Length (inches)	Weight (pounds)
24	14.5	45	82
27	20.5	50	110.5
30	28	55	145
33	37.5	60	186
36	48.5	65	233.5
39	62	70	288.5
42	77.5	75	351
45	95.5	80	422
48	115.5	85	501.5
51	139	90	590.5
54	165	95	688.5
57	181.5	100	797
60	226.5	105	916.5

Table XI. Average length and weight of ringed seals killed in various arctic localities and seasons. The figures do not incorporate seasonal changes in amount of blubber, nor do they account for growth of seals during the year.

Locality	Average of year's catch **		Offshore in summer ***		Open water in winter (floe edge)		Head of bays, etc. in winter. Tide rips, and on spring ice		From ice nearer floe edge in late spring	
	in.	lb.	in.	lb.	in.	lb.	in.	lb.	in.	lb.
South, east and west coasts of Hudson Bay & southwest coast of Hudson Strait *	38.5	69	40.5	73	34	47.5	42.5	90.5	39.5	70
Northern Hudson Bay, Ungava Bay, southeast coast Hudson Strait, northern Labrador	39.5	76	41.5	80	35.5	53	44	96	40.5	76.5
Simple coasts of southern Baffin Island (Lake Harbour & Cape Dorset areas) & east Foxe Basin (?)	40	80	42	83.5	36.5	56.5	44.5	103.5	41.5	82.5
Complex coasts of southern Baffin Island (Frobisher Bay, Cumberland Sound, Amadjuak, areas) & Repulse Bay area	43.5	99	42.5	103	39.5	72	48	126.5	42.5	102
East Coast Baffin Island, Northern Foxe Basin	44	104	43.5	107	40.5	76.5	48.5	131.5	43	105
High Arctic, Ellesmere, Devon, and north Baffin Islands	46	118	45	121	42	87	50.5	149.5	45	120

* We have few data on body measurements from these areas. A comparison of large numbers of skull measurements suggests that the average seals may be even smaller than shown here.

** This presumes the same hunting selection as found in southwest Baffin Island.

*** Differences of segregation on simple and complex coasts are accounted for.

The Meat Yield

It was found that extrapolation of the straight line expressing the length-weight relationship of the ringed seal (Fig. 8) passed close to points determined for data on harp seals (Sivertsen, 1941), harbour seals (Scheffer and Slipp, 1944; Fisher, 1952), and a single elephant seal (Laws, 1953). For this individual elephant seal, Laws gives the only detailed breakdown of weights of body parts of any seal species which appears to be available in the literature. It has been assumed that, since the general body form and length-weight relationship are similar in both species, the elephant seal and the ringed seal show the same proportionate weight of parts and organs. This is partly confirmed by less complete weighings of parts of ringed seals by the author (unpublished data) and by Stefansson (1944). From these combined sources the percentage weights of parts and organs of a ringed seal are given in Table XII.

It appears that about 27.5 per cent of a ringed seal is edible meat or viscera. Perhaps 2 per cent of the seal is edible, but unpalatable (gristle, major tendons, etc.) even to an Eskimo. Following Stefansson's (1946) dietary formula of 6 pounds of lean meat to 1 pound of blubber, about 30 per cent of a seal represents human food. Another 8 or 9 per cent of the seal, plus a varying amount of blubber, is edible by dogs, though in these days of trapping economy and large dog teams the dogs get a much larger share of the seal. The figure of 30 per cent of edible meat and fat in the average seal may be readily applied to the weights of seals given in Table XI to give the amounts of food available to the hunter on various coasts and in various seasons.

The bearded seal differs somewhat in shape, having less fat, and probably produces more meat proportionately. The liver, however, is generally held to be inedible, except in the southerly parts of the animal's range, and the same figure of 30 per cent edible meat and fat may therefore be applied to this species as well.

The Fat Yield and its Seasonal Variation

The coastal Eskimo is never hungry for fat. After feeding himself and his dogs with a sufficiency of the seal's blubber, there is always a good part left over. Perhaps only 25 to 30 per cent of the blubber of a seal of average fatness

Table XII. Percentage weights of organs and parts of an average ringed seal of late summer fatness. Based largely on figures from Laws (1953).

Part	Edible meat (man or dog)	Edible viscera	Dogfood only	Other	
Skin				6.0	
Blubber				32.0	
Meat	21.6				
Bone				16.2	
Foreflippers (including shoulders)	meat 2.0			other 2.3	
Hindflippers	meat 0.6			other 1.0	
Head			1.8	1.0	
Heart		0.5			
Liver		2.5			
Spleen			0.6		
Lungs			2.1		
Kidneys		0.3			
Stomach(empty)			1.7		
Intestines(empty)			2.1		Used occasionally as human food
Tongue			0.4		
Blood (most lost in butchering)				5.3	Could be utilized with better methods.
Totals	24.2	3.3	8.7	63.8 = 100 per cent	

is consumed as food. The surplus of blubber was burned as fuel by the primitive Eskimo, but at the present time the pressure stove has largely replaced the oil lamp as a source of heat, and much of the blubber is wasted. It has some value in trade between posts in the North, being shipped to areas where seals are scarce, and may yet prove to be of some value if it can be properly refined as a side product of commercial hunting.

The blubber of the average ringed seal from mid to late summer represents 32 per cent of the total seal weight; that of the bearded seal, about 27 per cent. In a large adult ringed seal, the blubber thickness of the chest may vary seasonally from about ¾ inch to 2 or more inches. It may decline slowly in the average seal from a winter peak of about 40 per cent of the animal's weight to a low in early summer of about 23 per cent of the animal's weight (McLaren, 1958b). The figures for the ringed seal are quite comparable with those for the harp seal, published by Sivertsen (1941), who studied the springtime decline in blubber in great detail. Probably the same order of seasonal change is shown by the bearded seal, the blubber of which may be reduced to a thin, fibrous layer ("white horse") in the early summer.

Figure 9 summarizes the seasonal changes in amounts of blubber. The timing of the seasons of fatness and leanness are essentially related to latitude, since the seasons of basking in the spring sun, break-up of the fast ice, and return to intensive feeding are all concerned in the development of the blubber layer. Figure 9 attempts to account for these latitudinal differences. The blubber changes are expressed in percentages of total weight, as well as in percentages of weight of an average seal; the latter expression enables us to estimate the amount of blubber on a ringed seal of known length (from Formula 7 or Table X). The same Figure may also be used to account for changes in the bearded seal, by reducing the percentages by 5. It must be borne in mind that individual variation of blubber thickness is rather great, and that this Figure only applies to the averages of large samples. For convenience, seasonal variation in blubber weight of seals of selected lengths is outlined in Table XIII.

The seasonal changes in blubber are important for their effect on the buoyancy, and hence loss by sinking, of seals. This problem will be discussed separately.

Seasonal changes in the amount of blubber of seals at various latitudes

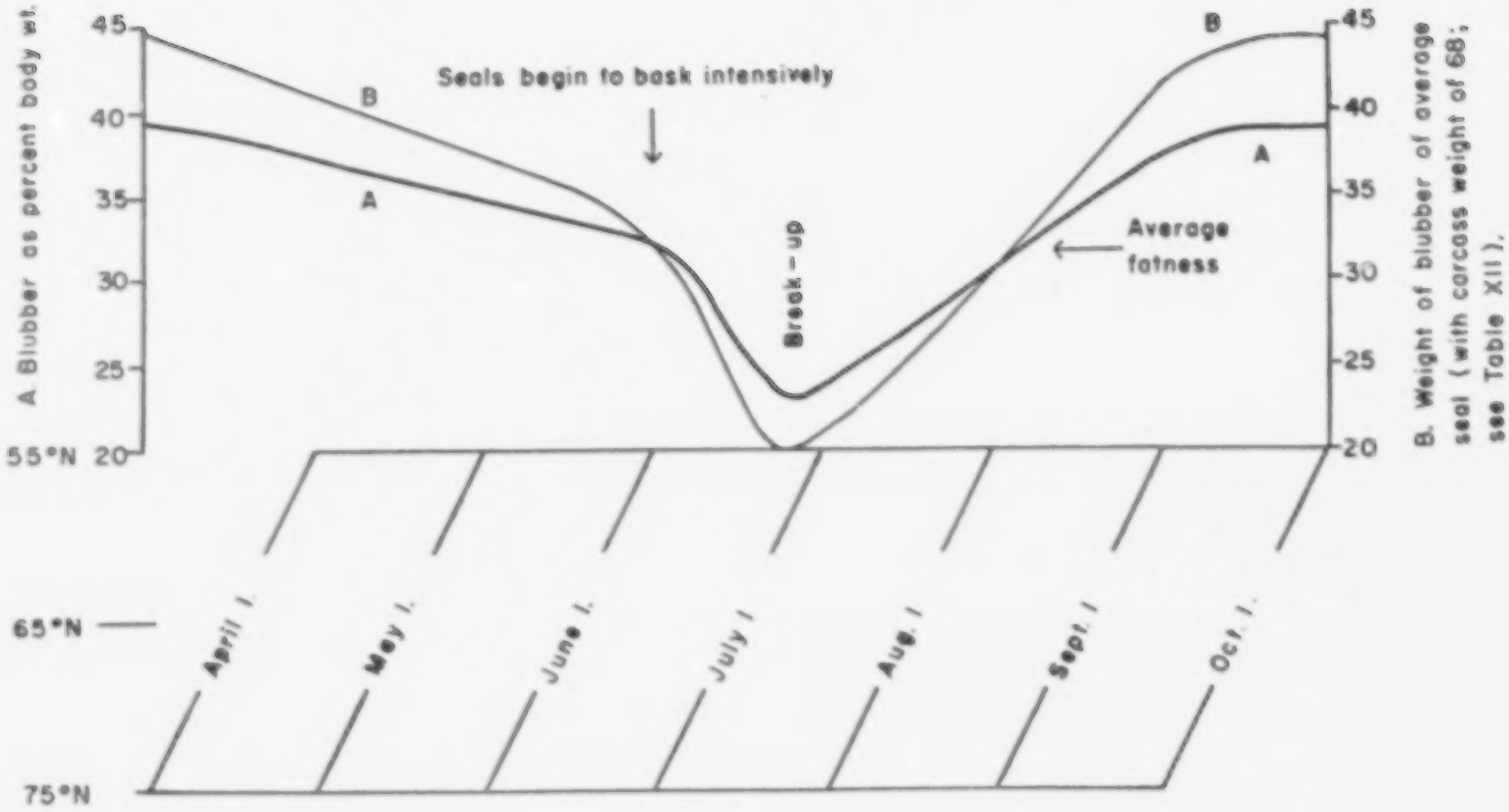


Fig. 9

Table XIII. Seasonal variation of blubber weight in ringed seals.

Length	Weight of average seal (mid to late summer)	Weight of blubber: late spring on ice: early summer in water	Weight of blubber: mid to late summer	Weight of blubber: early winter to early spring
inches	pounds	pounds	pounds	pounds
24*	14.5	4.5	4.5	6.5
27*	20.5	6.5	6.5	9
30*	28	9	9	12.5
33	37.5	7.5	12	16.5
36	48.5	9.5	15.5	21.5
39	62	12.5	20	27.5
42	77.5	15.5	25	34
45	95.5	19	30.5	42
48	115.5	23	37	21
51	139	28	44.5	61
54	165	33	53	72.5
57	181.5	36.5	58	80
60	226.5	45.5	72.5	99.5

* Seals of these lengths are likely to be seals of the year, which do not undergo prolonged fasting and thinning in spring.

Seal Skins

Ringed seal. Generally speaking the Eskimo of today can always obtain enough ringed seal skins for his local needs, a large surplus usually being available for trade or handicrafts. There are three main classes of ringed seal hides: skins from pups which have not shed their white, embryonic coats are sought almost entirely for their trade value and are known as "whitecoats"; skins from seals younger than one year, and before the first moult, are known as "silver jars" and are of some value as fur; hides from all older seals, or "common jars", are used locally or sold for their leather, or for use as trimming, although the hair is rather coarse.

The whitecoat ringed seal is hunted regularly only in a few arctic localities. Prices for its pelt have declined in the past few years, and competition from the better whitecoat of the harp seal will probably limit the expansion of any utilization of the ringed seal pup. It was an important item of trade particularly in Cumberland Sound, and concern has been expressed on a number of occasions about the intensity of the hunt in that area, it being felt that the heavy utilization of pups was contributing to a decline in the numbers of older seals. Actually no such decline is evident in Cumberland Sound, and is theoretically most unlikely. The average annual take of the whitecoats in Cumberland Sound in the 15 year period between 1921 and 1936 was 966 (varying from 41 to 2,638); for the period 1946 to 1957 the take averaged 406 (82 to 1,008; figures kindly supplied by the Hudson's Bay Company). There is no evident decline in the trade statistics of older skins during the earlier, more intense period of hunting. More to the point, the two years of highest whitecoat kill (1932-33 and 1934-45) were also the years of highest take of silver jars; obviously, the production of young cannot have been severely limited in those two years. Actually, it is probable that the arctic fox (Alopex) is a far more serious predator on whitecoats than the most efficient Eskimo hunter. In years of low fox numbers, when the trapping is poor, the whitecoat will be little preyed upon by foxes, and will offer some small replacement of income to the Eskimo. It would be wrong at the present time to consider any measures which would restrict utilization of ringed seal pups as an occasionally valuable resource.

The skins of older seals still find use in Eskimo clothing. The most common use still is in foot-gear; the uppers of one or two pairs of boots may be made from each seal skin.

Since the first-year skin is sold as fur, and the older skin is used or sold as leather, we can see that there will usually be a considerable difference in value of silver jar and common jar skins; the price ratio is often 2 or 3 to 1. It thus becomes important to outline the relative yields of these two sorts of skins which the hunter might secure. On most coasts about 15-20 per cent (average 17 per cent) of the year's take will be silver jars. Table XIV lists the theoretical catches of silver jars as percentages of the total catch in various seasons and areas; the figures are based on actual samples as well as on the considerations dealt with in the sections on maximum sustained yield and availability. Clearly, given a sufficiently high availability index, the most efficient hunting of the valuable young seal is possible in the winter, at the floe edge. However, the skins may be to some extent discoloured and worn by late winter, and the returns will not be so great. Also, in the spring the hunter can actually hunt specifically for the young seal, as it basks on the ice near its former birth lair. The pelt is quite prime by early June in latitude 65° N (about two weeks earlier at 55° and two weeks later at 75° N) and this might be the best season for the Eskimo seeking the valuable skin.

Other Species

The thick, tough hide of the bearded seal is very useful to the Eskimo; so much so, that it has been an important item of trade between arctic posts. It is essential for boot bottoms, and many of these may be removed from a single skin. It also makes the very best, supple lines for dog-team traces and harpoon lines, and is stronger and more wearing than an equivalent thickness of rope. A fully adult animal may produce from its mid section as much as 350 feet of half-inch line (A. W. Mansfield, personal communication).

The skin of the rarely obtained harbour seal is very much prized for clothing and trimming. The young of the year also commands a good price on the fur market.

Apart from their use as trade leather, the skins of the harp seal are said to be of the most suitable thickness for the covering of kayaks. They are also used as a less suitable substitute for bearded seal leather.

Table XIV. The proportion of first-year skins (silver jars) in the catch of ringed seals.

Type of coastline	Example	Silver jars as per cent of total catch: From early spring fast ice**	From late spring fast ice (shortly prior to breakup)	From boats in early summer	From boats in late summer	Inshore in winter (breathing holes and tide rips)	Off floe-edge in winter
Relatively simple coasts, with no nearby complex coasts of high pup production	Most of the coasts of Hudson Strait and Bay, Ungava Bay	23-25	17	17-20	20-22	0-5	40
Relatively simple coasts with nearby complex coasts of high pup production	Igloolik, Cape Dorset, Lake Harbour, Resolution Island, other localized areas	23-25	14-16	10-12	18-25	0-5	36-40
Relatively complex coasts, fiords or island-filled regions	Southwest, east and north Baffin Island including Frobisher Bay and Cumberland Sound	18-21	17	15-17*	20-22	8-15	40

* Presumes that little hunting takes place in inner reaches of bays, etc.

** Selection of silver jars often practised by hunters.

LOSS OF SEALS THROUGH SINKING

Large numbers of seals are lost by the native hunters when, after being shot and killed, they sink before they can be approached and harpooned. The loss may be quite large and serious and no account of the hunting productivity of an area can ignore this factor. It is proposed to deal first with the local and seasonal variations in this loss, and then with some possible remedies for the problem.

The primary cause of sinking is reduction of the blubber layer and consequent increase of density of the seal, fat being of low specific gravity. Table XV lists the losses of ringed seals observed during hunting trips in a number of eastern arctic localities. Although the data are few, they show that the largest losses in middle latitudes (Ungava Bay and southwest Baffin Island) occurred in July, shortly after the break-up of fast ice. The changes in blubber thickness are related to the season of basking on the spring ice, which is in its turn related to latitude. Hence loss of seals through sinking is also related to latitude and may be considered to follow the same form as the curves used to outline blubber change in Figure 9. That is, the proportion of sinking seals shows a slow, steady increase in the early spring, a sharp increase with the commencement of the basking season, a peak in early summer just after the ice departs, and then a fairly rapid decrease from the commencement of feeding in early summer to a minimum in autumn and winter.

The density of sea water is the second factor affecting buoyancy of the seal. In areas where water is fresher, seals sink in larger numbers (e.g. mouth of the Churchill River in February and, probably, in Moffat Inlet, northern Baffin Island, in early September; see Table XV). Most variation in density of sea water is caused by changes in salinity, and the effect of temperature, within the ranges concerned here, is negligible. Unfortunately, there are few observations relating density of surface waters to percentages of seals lost by sinking, and the problem must be approached indirectly for the present.

Reference to Table XV shows that about 53 per cent (22 of 42) seals killed in Ungava Bay and southwest Baffin Island in July were lost; the mean date of kill was July 14 and the mean latitude 61° N. From Figure 9, it can be seen that the average seal at this time would have about 22 parts blubber to 68 parts remaining carcass. Now the blubber of the harp seal, both adult and pup, has been found to have a specific gravity of 0.925 (Dr. Paul Montreuil, personal communication), and the specific gravity of ringed seal blubber may be considered

Table XV. Observations on percentages of seals lost by sinking in various seasons in various eastern arctic localities. Densities of sea water probably around 1.025, except where noted.

Date	Northern Baffin Island 73° N.		Northern Foxe Basin 70° N.		Southwest Baffin Island 64° N.		Southern Ungava Bay 58° N.		Mouth of Churchill River 58° N.	
	Per cent sinking	(Total killed)	Per cent sinking	(Total killed)	Per cent sinking	(Total killed)	Per cent sinking	(Total killed)	Per cent sinking	(Total killed)
									50*	4
Feb. 27										
Mar. 1-15					0	(2)				
Mar. 16-31					8	(12)				
Apr. 1-15	12	(17)			0	(9)				
July 1-15					60	(15)	45	(20)		
July 16-31							57	(7)		
Aug. 1-15					17	(24)				
Aug. 16-31					15	(34)				
Sept. 1-15	39*	(26)	6	(18)	4	(23)				
Sept. 16-30	0	(10)	3	(29)	3	(32)				

* Hunting in relatively fresh surface waters.

to be about the same. Since the density of open-sea water, offshore in Hudson Strait and Ungava Bay, is about 1.025 near the surface (see Dunbar, 1958), there is enough information available for an estimate to be made of the effect of sea water density upon sinking of seals.

Since about 50 per cent of seals in mid July sink, it may be assumed that the average seal is balanced between sinking and floating, or has a specific gravity equal to that of the sea water.

Then,

$$\text{Volume of seal} = \frac{90}{1.025} = 87.80$$

$$\text{Volume of blubber} = \frac{22}{0.925} = 23.78$$

$$\text{Volume of remaining carcass} = 64.02$$

$$\text{Weight of carcass} = 68$$

$$\text{Specific gravity of carcass} = \frac{68}{64.02} = 1.063$$

The specific gravity of the carcass, without blubber, is assumed not to vary with season. Then in mid winter, the average seal (see figure 9) will have 44 parts blubber and, still, 68 parts of remaining carcass. Thus at this time the whole animal will have a specific gravity of:

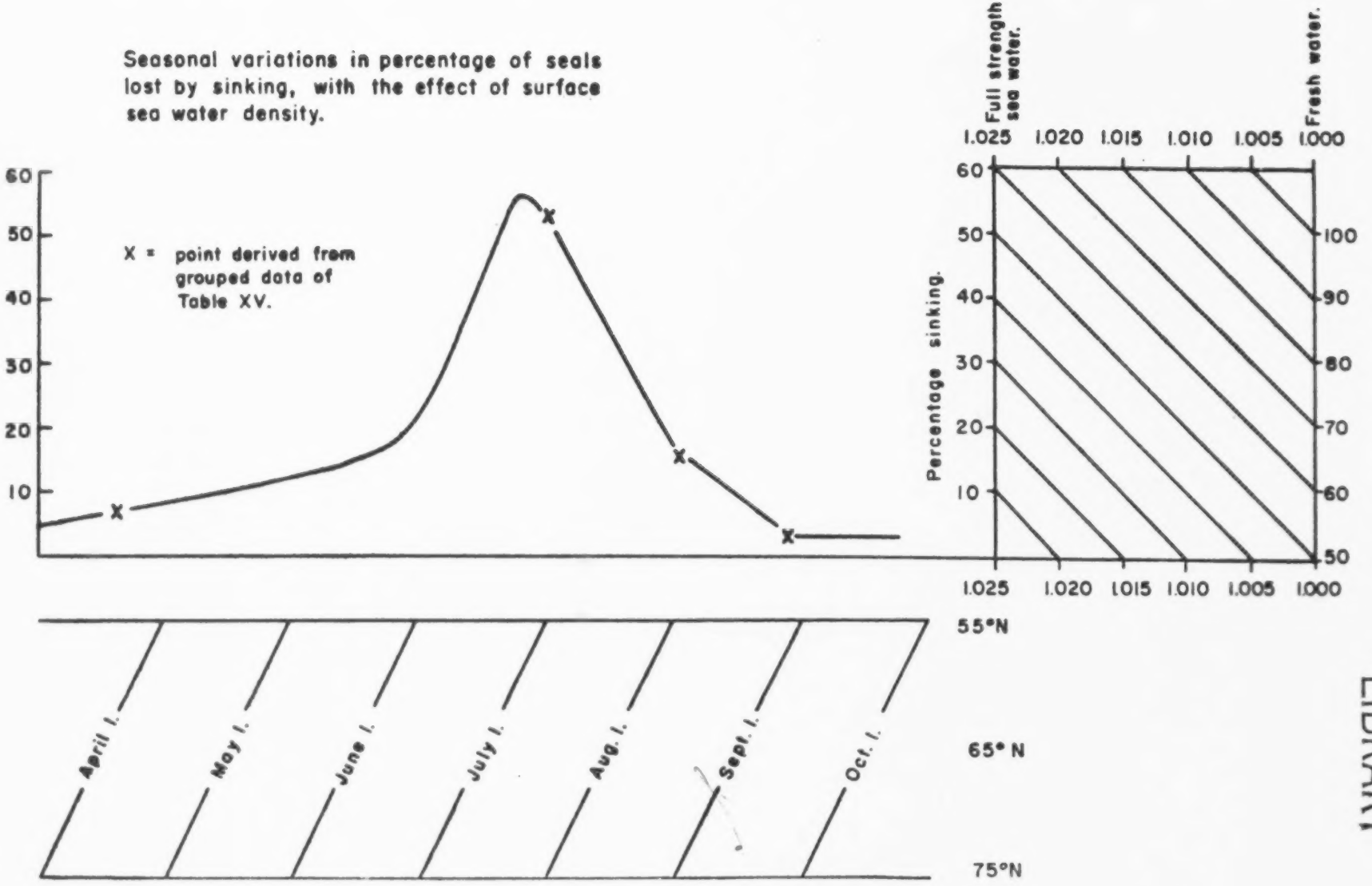
$$\frac{44 + 68}{0.925(44) + 1.063(68)} = 0.991$$

This means that about 50 per cent of seals will float in fresh water of specific gravity 1.0 in winter.

From these facts and theoretical considerations the graph of Figure 10 has been constructed. The following example shows the way in which this graph is used to predict loss by sinking.

Fig. 10

Seasonal variations in percentage of seals lost by sinking, with the effect of surface sea water density.



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Question. In late July in Chesterfield Inlet, where the surface salinities are presumed to be about half sea strength, what percentage of ringed seals will be lost by sinking?

Answer. From the point in the lower part of Figure 10, for latitude 63.5° N. and the end of the third week of July, run a line vertically up to the curve. From where this vertical line intersects the curve, run a line horizontally to the right until it intersects the vertical line of sea-water density of 1.0125 (half normal sea strength). This point of intersection lies very close to the sloping line of 65 per cent loss.

Loss of seals before the departure of the fast ice (June and early July in middle latitudes) is not so serious as Figure 10 might imply. Most seals at this season are hunted on the fast ice, and those shot in the water at the floe edge are generally immature and have not yet come into the fast ice to bask, fast and lose blubber. A few seals may be shot dead on the ice and yet slide back into their breathing holes with a drop of the head. Such seals almost never float, for they are thin, and melt water has freshened the surface water just under the ice. It can be seen that, except in regions of low surface salinities, the problem is acute only for the hunter from boats in the early summer. This is a season when hunting activity may be quite high, since weather is often at its best then, with warm sun and light winds. In middle arctic areas, particularly in regions of exposed coastlines, it may be the only persistently calm period in the open-water season until late autumn. It is small wonder that one of the most common questions of many individuals and agencies concerned with the North has been "What can be done about this loss?".

The most extreme solution which has often been suggested is to return to the method of hunting with the harpoon alone from the kayak. Certainly this was a method quite sufficient for the needs of the primitive Eskimo, with his small dog teams and lesser tendency to congregate, but such hunting is simply too arduous and unproductive for modern needs. A better suggestion is that the kayak, being highly manoeuverable and quiet, is an ideal hunting craft for the Eskimo equipped with rifle. This is to some extent true, for the seal can be approached closer before being shot, and reached quite rapidly after being killed. However, the chief objections to the

kayak still remain: it is a fragile, even dangerous craft, in spite of the feats shown by the polar Eskimos of Greenland in the open sea, and it is difficult to build and lasts only about two years (Manning, 1944). It is the author's belief that a powered canoe, being faster, is probably the best boat for hunting in the sinking season; it also appears to have a higher catch per unit effort at any season than larger craft.

The most commonly suggested solution to the problem of sinking is the use of some sort of harpoon-projectile. A variety of harpoon guns has been suggested, including, for economy, various models of crossbows. The most ingenious system which has been outlined to the author (F. Symington, personal communication) is a weapon which would fire a harpoon with a small compressed-gas cylinder which, on contacting and penetrating the seal, would inflate a float. Although it is not the author's intent to dismiss attempts at perfecting a harpoon gun, it is believed that all such suggestions fail to account for the realities of seal hunting. Seals cannot generally be approached very close, and the limits of range and accuracy of any conceivable harpoon weapon would be inadequate in all but a very few instances. Seals which come up close enough to a boat to be shot with a harpoon gun are rare indeed, and often give the barest opportunity for a snap shot with a rifle. A rifle is also much less clumsy and due to the speed of the projectile, much more accurate on moving targets. On the balance, it is believed that the harpoon gun is not the solution to loss of seals through sinking.

The value of seal nets in this season is obvious, for there can be no loss from sinking involved.

There is, in fact, no possibility of eliminating entirely loss of ringed seals through sinking. If it is necessary to hunt at all during the season of greatest sinking, then the Eskimo can certainly take precautions to limit the loss. Hunting from large boats, particularly Peterheads, is not to be encouraged. The small .22 calibre rifle, which often wounds without killing outright, especially with "short" bullets, should be used when possible. The Eskimo should train himself in the use of throwing a light harpoon, for distances of a few yards, and perhaps a heavy, weighted harpoon could be at hand to secure seals which can be seen sinking slowly into the depths beneath the bow of the hunting boat.

The sinking of bearded seals is a somewhat different problem. They will generally sink in the same seasons as the ringed seal, but being on the average somewhat thinner at all seasons, they may sink at any time of the year. They are often shot when lying out on the floating pack ice. Even when killed immediately, they sometimes roll off the ice and almost always sink. However, shooting on the ice is a way to ensure small losses. The Eskimos make a practice of shooting the bearded seal in the back or belly as it "humps" over during the dive. This wounds the animal, and after a chase it may usually be harpooned quite easily. This seems much the most efficient way of preventing loss by sinking when hunting in the summer, and the Eskimos only rarely forget the rules and shoot to kill during the excitement of the chase.

DISCUSSION OF SOME HUNTING METHODS AND IMPLEMENTS

Although reference has been made to hunting methods and implements in the preceding text, particularly in the sections on availability of seals and loss through sinking, it seems best to rearrange some of the more appropriate comments here. This is not meant to be a review of all hunting techniques, and the discussion is confined to comparisons of the efficiency and productivity of the basic methods and implements with a few suggestions for improvement. By far the most complete account of the hunting methods and implements of the eastern arctic Eskimos is given by Manning (1944), to which the reader is referred for fuller information.

A. Boats. Essentially four classes of boats are used: the kayak, the canoe, the whaleboat, or trapboat, and the larger, half or fully decked Peterhead. The canoe and Peterhead are almost always powered, while the whaleboat often lacks an engine. Of these boats the canoe appears to be the most productive in summer, giving perhaps twice the kill per hunter (2 men per canoe) as compared with powered Peterheads and whaleboats. However, the Peterhead produces more seals per boat (4 to 6 hunters per boat), and thus in effect has smaller overhead costs. The bigger craft is a steadier shooting platform, and is thus better for hunting on days when a slight chop on the water may reduce the efficiency of the canoe. When seals are sinking, the canoe is definitely better, being faster and more manoeuverable. Any further improvement of hunting boats will probably be in the development of more efficient, less expensive engines. In future Eskimo settlements, with their

anticipated diversified economies, the supply of meat might best be obtained by a large, co-operative schooner. This larger ship could act as tender to a group of small boats, from which more efficient hunting could be carried out.

B. Rifles. The Eskimos use rifles ranging in size from the small .22 rimfire weapon to large centrefire weapons of .30 calibre; rifles of .25 calibre are most popular in some areas. The use of the .22 rimfire rifle is recommended for hunting seals in the sinking season, for wounding bearded seals with a head shot, for forcing wounded seals to dive and increase their exhaustion when they are out of range, and generally whenever close shots are possible. The .22 cartridges are, of course, inexpensive. Heavier rifles are very good for longer shots when the shooting platform is steady. They are necessary for most winter hunting in the open water and for killing seals on the fast ice in spring, but when they are used indiscriminately in the summer much valuable ammunition may be wasted.

C. Nets. These have not been used nearly as much as they should have been. Among the objections which have limited their use is their expense and need of constant repair, and perhaps most of all their elimination of the pleasure of the hunt, for the Eskimo enjoys hunting with a rifle quite as much as does a white sportsman. Nets have found their greatest use in areas of real need: for example, they are used along the south side of Hudson Strait, where ringed seals are scarce, to catch migrating white whales and harp seals. The great improvement which has come with the use of nylon is well illustrated by the catch of 500 ringed seals which were taken with a 7-inch mesh net, 150 feet long by 10 feet deep, at Herschel Island in September 1956 (J. G. Hunter, unpublished observations). The net appeared to be about four times as efficient as an equivalent cotton net. It would be valuable to introduce this method to the eastern arctic, especially where there are meat demands for wage-employed communities. One of the most valuable resources which could be obtained in this way is the harp seal. This animal is known to travel in great numbers through McLelan Strait, near Port Burwell, every autumn around freeze-up, and has been taken in quantity there by Eskimos using much less efficient means. It is also taken by nets in its migration at several points on the Labrador coast, and particularly near Blanc Sablon, Quebec. The harp seal herds could certainly stand any utilization on the local, subsistence level in the arctic.

D. Hooks and set-guns. A controversy has developed about the use of these methods by the eastern arctic Eskimos. In the central arctic, where the natives depend to a greater extent on seals killed at their breathing holes, seal hooks, which trap and hold the seal in its breathing hole, are used with great success. It has been suggested by some observers that the seal hook is a menace, since the hooked animal prevents others from having access to the breathing hole. It appears, however, that each seal has generally more than one breathing hole, and therefore this objection is not likely to be valid. Seals have a remarkable ability to go without breathing for as much as 15 or 20 minutes (Scholander, 1940) and this too makes it unlikely that the seal hook will be the cause of the unaccounted losses. The same reasoning applies to the set harpoon gun, which is placed outside the seal hole and probably does not frighten the seals as much; however, it is a much more expensive method than the simple hook.

USE OF THE TABLES AND GRAPHS IN PREDICTION AND ANALYSIS

This section will demonstrate practical use of the tables and graphs in answering specific questions. The questions will be simple ones at first, and then more elaborate, to demonstrate the use of several separate tables and graphs in conjunction.

1. Question: How many ringed seals may be taken per year by Eskimos of Cumberland Sound, without depleting the stocks of seals?

Answer: Reading directly from Table III (Area 6), a maximum sustainable yield of about 5,500 is possible.

2. Question: How many bearded seals may be killed per year by Eskimos of Cumberland Sound without depleting the stock.

Answer: From Table IX, about 770 bearded seals may be taken per year in the waters of Cumberland Sound, Hall Peninsula, Frobisher Bay and Resolution Island, which have a total of 12,872 square miles of water within 10 miles of their shores. Hence, $770 \times \frac{4,613}{12,872}$ or about 275 seals may be taken in Cumberland Sound, with its 4,613 square miles of water (from Table III) within 10 miles of shore.

3. Question: How many ringed seals may be killed by hunters from large powered boats (Peterheads or whaleboats) on good hunting days in summer off Cape Dorset, out of Port Harrison and out of Sugluk?

Answer: From Table VII we see that about 0.1 seals may be taken per hunter per day per unit summer availability index from large powered boats. The availability indices for summer are listed in Table III. The answers are then as follows:

Off Cape Dorset (in locality 11, Table III)
0.1 x 18 = 1.8 seals/hunter/day

Out of Port Harrison (in locality 18)
0.1 x 9.7 = 1.0 seals/hunter/day

Out of Sugluk (in locality 15) 0.1 x 2.6 = 0.3 seals/hunter/day

4. Question: How many bearded seals may be killed per good hunting day in summer by boats hunting out of Pond Inlet, Ungava Bay, and Lake Harbour?

Answer: Reading directly from Table IX, about 0.3 seals may be killed per day by each boat out of Pond Inlet, about 0.5 out of Lake Harbour, and about 1.3 out of Ungava Bay.

5. Question: How many ringed seals may be killed by each hunter on a good day at the floe edge in spring at Admiralty Inlet and off the Belcher Islands?

Answer: From Table VII, about 0.12 seals may be killed per hunter per day per unit winter availability index at the floe edge in spring. The winter availability indices are listed in Table III. The answers are thus as follows:

Off Admiralty Inlet (locality 1) 0.12 x 7.3 = 0.9 seals/hunter/day

Off Belcher Islands (locality 20) 0.12 x 6.1 = 0.7 seals/hunter/day.

6. Question: How many seals might a hunter kill on sunny days on the ice of the Igloolik area and near Povungnituk on May 15, June 15, and July 15.

Answer: From Table VII we see that about 0.63 seals may be killed per hunter per day per unit availability index on fast ice. The availability index varies seasonally and locally as shown in Figure 6.

Igloolik is at latitude 69° 30' N., while Povungnituk is at about 60° N. The line running upwards vertically from the point on the lower side of Figure 6 for latitude 60° and May 15 intersects the curve at about 1.5, the availability index for this latitude and this date. The product of 0.63 and 1.5 is about .95, which represents the average number of seals which can be taken. Applying the same reasoning to different dates and latitudes we get:

On May 15: 0.9 seals per day near Povungnituk
0.5 near Igloolik
On June 15: 5.4 seals per day near Povungnituk
and 1.3 near Igloolik
On July 15: 0 seals per day near Povungnituk
and 3.8 near Igloolik

7. Question: How much will the average seal from the floe edge of Igloolik weigh in winter and how much meat will it produce? How much bigger than the average seal from the floe edge at Port Harrison will it be, and how much smaller than the average seal from the tide rips of the Amadjuak area of southwest Baffin Island?

Answer: Reading from Table XI, we find that the average seals from the above-mentioned localities and seasons weigh 76.5, 47.5 and 126.5 pounds respectively. About 30 per cent of these weights represents food for Eskimos (see Table XII). Actually, the seals will weigh somewhat more, as the blubber increase for the winter season has not been accounted for. The weights may be corrected from Figure 9, or Table XIII to give weights of approximately 53.5 pounds, for floe-edge seals of Port Harrison, 85.5 pounds, for seals off the floe edge near Igloolik, and 142 pounds for average seals killed in the tide rips near Amadjuak.

8. Question: What percentage of seals killed will be lost by sinking on August 1 in the mouth of the Churchill River, where the water is about ¼ sea-strength, and off Cape Dorset on August 10, when the water is full sea-strength at surface.

Answer: From the lower part of Figure 10, for latitude 59° on August 1, run a line vertically until it intersects the curve. From this intersection run a line horizontally to the right until it intersects the vertical line at sea-water density of about 1.006 (about ¼ full sea-strength). This comes close to the oblique line of about 60 per cent loss. The same reasoning applied to Cape Dorset on August 10 implies a loss of about 20 per cent.

9. Question: How might the general conditions in terms of production of food be compared in areas where seals are almost the only source of meat, say in the Belcher Islands, Wakeham Bay, Pond Inlet and the Cape Dorset area?

Answer: Since the bulk of seals are killed during the open water season, and since the conditions in winter reflect quite closely the conditions in summer anyway, it may be assumed that the summer availability index (Table III) gives a good indication of general conditions of a coastline. Ringed seals vary markedly in size, however, and this fact must be considered. It is suggested that an indication of coastal suitability is the product of the summer availability index and the average weight of ringed seals (from Table XI) of that coast. Thus, for the above listed localities:

Belcher Islands (area 20, Table III):9.6x69=662
Wakeham Bay (area 14): 8.2 x 76 = 623
Pond Inlet (area 2): 12.3 x 118 = 1451
Cape Dorset (area 11): 18.2 x 80 = 1456

This indicates that Cape Dorset and Pond Inlet are equally suitable for the hunter of ringed seals while each is more than twice as good an area as the Belcher Islands or Wakeham Bay.

The bearded seal should also be considered in such an analysis. Its availability indices are listed in Table IX, and the average weight is approximately 465 pounds (see p. 57). However, the bearded seal is killed regularly only during summer, and its availability indices should therefore be reduced to, say, one half of the figures listed in Table IX. The suitability of the above-mentioned areas in terms of bearded seals is then:

Belcher Islands: 0.5 x 2.0 x 465 = 465
Wakeham Bay: 0.5 x 1.5 x 465 = 349
Pond Inlet: 0.5 x 0.5 x 465 = 116
Cape Dorset: 0.5 x 1.0 x 465 = 233

Although not nearly as much reliability can be attached to the figures for bearded seals, they can be added to the more firmly based ringed seal figures shown above to get a more accurate assessment of the suitability of coastlines. The comparison of the four areas, then, with the figure for Cape Dorset reduced to unity, is:

Cape Dorset:	1.00
Pond Inlet:	.92
Belcher Islands:	.67
Wakeham Bay:	.55

This means, for example, that the individual native of Wakeham Bay is about twice as hard-put to make a living from seals as a native from Cape Dorset.

Another view of the same problem might be made by dividing the maximum sustained yield of seals of a given coastline from Tables III and IX by the number of Eskimos inhabiting that coastline. When multiplied by the amount of meat per seal (Table XI for the ringed seal, and 30 per cent of 465 pounds for the bearded seal, this gives a figure for the maximum amount of meat which may be extracted per person on various coastlines. For the above areas the figures are:

Region	Equivalent areas of Table III	Maximum sustained yield Bearded	Ringed	Number of Eskimos	Potential pounds meat per Eskimo per year
Cape Dorset	11 & 12	240	5,520	425	420
Pond Inlet	2	136	5,300	250	825
Belcher Islands	20	522	4,000	190	820
Wakeham Bay	14	187	1,630	170	370

It appears from this analysis that the Pond Inlet area and the Belcher Islands may be undersettled, from the point of view of available resources.

10. Question: An Eskimo of average hunting ability is licensed to supply meat to residents of Rankin Inlet. He brings this meat to a refrigerator plant. He traps foxes during winter, and plans to hunt between May 1 and October 1 in the most efficient way possible. He will hunt by himself with his dog team in the spring and will have his unpaid son as an assistant in the powered canoe during summer. During the spring he will hunt on the fast ice only during sunny days (3 out of 5) when the seals haul out on the ice in increasing numbers, while on half the dull days he will go to the floe edge (1 out of 5 days). After commencement of break-up, when it becomes safer and more profitable to hunt by canoe, he will go out only on calm days, which probably number about 15 in July, 10 in August and 6 in September. His family consumes 4 pounds of meat and 0.7 pounds fat per day, or 1460 lb. meat

and 255 lb. fat per year. His team of 8 dogs must be fed 1 pound of meat and ¼ pound fat daily during the working season from December 1 to July 1, and ½ pound meat and ¼ pound fat when idle, a total of 2430 lb. meat and 730 lb.fat per year. He also requires 3 bearded seal and 6 common jar skins for boots and line, and about 600 pounds of blubber for burning in a lamp or stove per year. Overhead expenses also include gasoline at $2.00 per day's hunt, ammunition at $30.00 per year, and depreciation of equipment of $60.00 per year. He is able to sell seal meat in bulk for human consumption at 10 cents per pound and dog food (offal) at 5 cents per pound, while there is a market for a seal liver among white residents at 50 cents per pound. He is able to sell blubber at only 3 cents per pound. He can sell silver jar skins for which he obtains $3.00, common jar skins for $1.00 and bearded seal skins prepared as line at $5.00. Given these data, what will be his season's profit?

Answer: The basic data are derived as follows:

Catches of seals per day's hunting are equal to the availability indices multiplied by the catches per unit effort.

Ringed seals at floe edge (Tables III & VII) = 5.2 x 0.12 = 0.62 seals per day.

Ringed seals on fast ice (Table VII & Fig. 6) = 0.63 seals per unit availability index per hunter/day.

Ringed seals in summer (Tables III & VII) = 9.5 x 0.2 (x 2 hunters) = 3.8 seals per day.

Bearded seals in summer (Table IX) = 1.0 seals per day.

The weights of ringed seals, unadjusted for blubber change, are taken from Table XI:

At floe edge; 47.5 pounds

On fast ice; 90.5 pounds

In the water in summer; 73 pounds.

The average weight of bearded seals is 465 pounds (see p. 57).

The proportion of silver jars on such a coastline is taken from Table XIV.

At floe edge; 40 per cent, but the pelts are unsuitable in late spring.

On fast ice; 17 to 24 per cent, averaging 21 per cent.

In summer; 17 to 22 per cent, averaging 20 per cent.

Given the above facts, it will be seen that on the commencement of hunting on May 1, about 0.62 seals may be taken per day at the floe edge, while (from figure 6) about 0.63 x 0.7, or 0.44 seals, can be taken on the fast ice each day. However, the fast ice seals are larger, averaging 90.5 x 0.44, or 40 pounds of seal per day, as compared with 47.5 x 0.62, or 30 pounds of seal per day at the floe edge. Also, silver jars will be taken on the ice. Thus floe edge hunting will not pay except on the 1 out of 5 days which is dull, keeping the seals off the ice.

We may determine the number of seals killed on the fast ice at this latitude (62° 45' N.) by integrating the curve in Figure 6; this is most easily done by averaging the availability indices of 3-day intervals between May 1 and July 6, when break-up occurs at this latitude. The average availability index for this period is 3.5; hence 3.5 x 0.63, or 2.2 seals, may be killed by our hunter on an average day during the period of fast-ice hunting. He may hunt on about 38 days (3 out of 5) during May 1 to July 6 and this will give him 84 seals. On the 13 days (1 out of 5) suitable for hunting at the floe edge, 13 x 0.62, or about 8 more seals may be killed.

The products of the hunt in the spring season are calculated from the percentage weights of parts of the average seal listed in Table XII.

Weight of meat from fast ice = 25 per cent of 84 seals x 90.5 lb. = 1905 lb.

Weight of meat from floe edge = 25 per cent of 8 seals x 47.5 lb. = 95 lb.

Weight of liver = 2.5 per cent of (84 x 90.5) + (8 x 47.5) = 194 lb.

Weight of dog food = 8.7 per cent of (84 x 90.5) + (8 x 47.5) = 695 lb.

The average date of kill is about June 15, and the average seal is then about 32 per cent blubber (see Fig. 9). Thus the weight of blubber produced = 32 per cent of (84 x 90.5) + (8 x 47.5) = 2554 lb.

Number of silver jar skins taken (Table XIV and above) = 21 per cent of 84 = 18; and common jar skins = (84 - 18) + 8 = 74.

For hunting in summer, similar reasoning is applied:

Between July 6 (break-up) and September 30, the Eskimo will be able to hunt on about 28 days (12 in July, 10 in August, 6 in September). This will result in 28 x 3.8 = 106 ringed seals being killed, but many of these will be lost by sinking. The average surface salinities around Rankin Inlet in summer are probably about 28 parts per thousand, which implies a surface density of approximately 1.022. Using Figure 10, as in Question 8 above, and integrating roughly for the entire season by averaging the percentage lost in 12 evenly spaced trips between July 6 and 31, 10 evenly spaced trips in August, and 6 in September, we get a figure of 31.5 per cent loss for the entire season (50 per cent are lost in July, 21.5 per cent in August, and 10 per cent in September). Thus the total kill will be only 0.685 x 106, or 72 seals.

The products obtained from these 72 ringed seals will be as follows:

In meat: 72 seals x 73 lbs. x 25 per cent = 1314 lb.

In liver: 72 x 73 x 2.5 per cent = 131 lb.

In dog food: 72 x 73 x 8.7 per cent = 457 lb.

In fat: The average date of kill is about August 6, but the average date of retrieved seals (adjusted for higher loss by sinking in earlier season) is about August 16, when the average seal (again from Fig. 9) is again about 32 parts of blubber to 68 parts remaining carcass. Thus the amount of blubber taken from the season's catch of ringed seals is 72 x 73 x 32 per cent = 1685 lb.

In silver jar skins: 72 x 20 per cent = 14.

Common jar skins: 72 - 14 = 58.

During this same season of 28 days, a total of 28 bearded seals may be taken, of which none will have been lost by sinking; each averages 465 pounds. The products of the season's catch will be as follows.

In meat: 28 seals x 465 lb. x (27.5 - 2.5 per cent) = 3255 lb. (liver discarded).

In dog food: 28 x 465 x 8.7 per cent = 1133 lb.

In fat: The average date of kill will be about August 6. The average bearded seal has 5 parts less fat (see p. 62) than an average ringed seal in the same season; that is, while the ringed seal in Figure 9 has 28 parts blubber to 68 parts remaining carcass on August 6, a bearded seal will have 23 parts blubber to 68 parts carcass. Since a 465 pound bearded seal of average fatness will have a carcass weight of 465 x (100 - (32-5) per cent), or 340 lb., the blubber of the average seal killed on August 6 will weigh $\frac{340 \times 23}{68}$, or 115 lb. Thus, the total weight of bearded seal blubber taken in the season will be 28 x 115, or 3220 lb.

Also, 28 bearded seal skins will be taken.

The economics of this problem is summarized in Table XVI. It can be seen that the profit accrued is quite a good one, especially if the hunter can gain further cash income from trapping in winter.

METHODS OF COLLECTING AND RECORDING USEFUL INFORMATION AND MATERIAL

Throughout the preceding text many shortcomings will have been obvious. Many useful observations could be made easily, with little time and trouble, and readers could furnish a great deal of what is needed. Other observations are a bit more demanding, but it is hoped that some pleasure will be gained from the insight they give into life of the seals and the economic problems of the Eskimo.

In the list which follows, the information and material required is broken down into categories. Those matters on which information would especially be desirable are underlined, as are any important points to procedure.

Table XVI. The economics of a hypothetical season's hunting near Rankin Inlet.

Products	Amount taken	Hunter's annual need	Total remaining	Unit price	Gross profit
Seal meat for humans or dogs	6564	1460 lb. (+145 lb. for dogs)	4959	$0.10	$495.90
Dog food (offal)	2285 lb.	2430 lb. (some needed from meat)	none left	$0.05	
Ringed seal livers	325 lb.		325 lb.	$0.50	$162.50
Fat	7460 lb.	1585 lb.	5875 lb.	$0.03	$176.25
Silver jar skins	32 skins		32 skins	$3.00	$ 96.00
Common jar skins	132 skins	6 skins	126 skins	$1.00	$126.00
Bearded seal skins	28 skins	3 skins	25 skins	$5.00	$125.00
					$1,181.65

His expenses in hunting during this season are $146.00.
Hence, his net profit is about $1,000.00.

Any communications concerning these matters should be sent to this office. We will be quite willing to answer any questions which might be asked, and will supply materials needed for the collection of data or seal jaws.

The address of this office is:

Fisheries Research Board of Canada,
Arctic Biological Stn.,
Box 400, Ste Anne de Bellevue, Quebec.
~~Montreal, Quebec.~~

1. Samples of Jaws for Age Determination

Knowledge of age composition of certain seal populations is important in estimating mortality rates (see pp. 10 - 16) and understanding distribution at certain seasons (see pp.46-52). For this study, the right lower jaws of many specimens are required, these roughly cleaned, should be put into an airtight container and simply allowed to rot. Large numbers of jaws from the same season and site can be kept in the same container, but seals from different sites or seasons must not be mixed. The basic separation of sites and season is as follows:

A. Jaws from seals from under or on the fast ice, before the period of break-up are needed more than any other class. The origin of jaws should be rather precisely known. If from an Eskimo camp, the position of the camp and the general winter hunting area should be known. The most valuable collections from this season would be jaws taken from seals at their breathing holes, in winter, at known distances from the floe edge of simple (little-indented) coasts, fiord coasts, and highly complex coasts with many islets. Winter residents of the north and east coasts of Baffin Island (fiord coasts), and southwest Baffin Island (complex coasts), and Ungava and Hudson Bays (simple coasts) are urged to collect such samples from the Eskimos.

B. Jaws from the floe edge in winter, to assess more accurately the representation of immature seals off-shore in winter, will be valuable and may be easy to secure. These should be kept in batches by month.

C. Samples from summer hunting, in the open-water season, should be kept grouped by area. Not much accuracy of origin is necessary here as they would be used largely for mortality rate studies.

D. Any jaws for which no information is available should be kept anyway, but it must at least be known in what year they were taken.

2. Observations of Numbers of Seals Killed During the Year

One cannot help but think that many of the estimates given for numbers of seals killed in different regions of the North are not too trustworthy. For example, two different agencies estimated the kill at Pond Inlet at 10,000 and 4,500 respectively in the same year. The following techniques might be used for more accurate assessment:

A. Although this might be difficult in some areas, the Eskimos, perhaps the "boss" of each camp, might be asked to keep accurate statistics on the catch. This would merely be a matter for him of ticking off numbers on a calendar, or some such procedure.

B. Careful statistics could be kept by trading agencies on the number of silver jars (seals of the year) turned in by Eskimos, especially in years of good price. Almost all of these skins will be turned in for trade, and their proportion in the total kill is known quite well.

3. Summer Census of Seals from Boats

The procedure is carefully outlined on pages 17-20 If any individual finds it his good fortune to be travelling on a calm day in the north, such observations would be of great value. Those who in their work hire a native boat to get from one point to another might discourage any hunting on route on such days and get the natives to help with the census.

4. Spring Census on the Fast Ice

A. Counts of seals on known areas of fast ice are of value. These must be accurate. The observer should seat himself on a high point and scan every possible area with binoculars. The heat haze and mirage over such ice in spring are problems. The observer should not try to count the seals at too great a distance, but should limit his census to areas of ice on which the seals are clearly visible. The exact area of fast ice observed should be noted. This can often be

done simply by marking out the area on the local topographic sheets. If no such map is available, a sketch map should be made for future reference to published maps. It is most important, of course, to give the date of observations. The most valuable observations for the present studies would be series of censuses carried out on the same area of fast ice through the entire basking season; the area observed should be free of hunting by Eskimos. Such observations could quite easily be carried out by any scientific party camped in an isolated area on the arctic coasts.

B. Another aspect of the same problem is the determination of the amounts of fast ice which form on various coastlines. A short consultation with knowledgeable Eskimos using the 8 mile to 1 inch topographic sheets should clarify this. They should be asked to draw in the average late-winter floe edge. They might be asked also to define areas where the ice is more suitable for pup production, where the very old seals are found in winter, and where there are areas of poorly covered, unstable fast ice at this season.

5. Observations on Catch per Unit Effort

Many reports on the productivity of hunting are marred by vagueness. It is often stated that the "seals are scarcer than last year" without any reference to actual numbers killed per hunting trip. It seems likely that most such statements fail to distinguish between actual seal numbers and the problems of weather, Eskimo initiative, etc. The observations should be made as follows:

A. From boats in summer. The following information should be recorded: weather (generally only flat calm days will be suitable); the number of hours spent sealing; the general area ("Off Cape Dorset"; "head of Frobisher Bay"; "Moffat Inlet, Admiralty Inlet"); the type of boat used (Peterhead, whaleboat, trapboat, canoe, or kayak); the number of hunters involved; the number of seals killed, including those which sink. Any time a white resident of the north accompanies an Eskimo hunting party for a day's pleasant offshore sealing, this sort of information would be very easy to get. The Eskimos themselves might be encouraged in some areas to record the same information.

B. From fast ice in spring. The number of seals, per hunter, per hour's hunting time are needed (or per full day's huntingtrip if necessary). The area and date must be recorded. It should be noted whether the weather was sunny, cold and windy, etc., as this affects the numbers of seals on the ice.

C. From the floe edge. The number of seals per hunter per hour (or day), the area, the date, the weather, and ice conditions (if no ice at floe edge, or if ice jammed there) should all be recorded.

D. From breathing holes and tide rips. Number of seals per hunter per hour (day), area, date, and wind conditions (as these affect hunting at breathing holes) should all be recorded.

6. Loss of Seals through Sinking

This information must be included in reports of catch per unit effort (number 5, above). There are two observations which would be very useful here.

A. The number of seals sinking out of the number killed, and the date are the first necessities.

B. When possible, an estimate of the relative saltiness of the sea water should be made. A useful approximation can be gained by diluting a known quantity of the collected sea water with a known quantity of fresh water until the mixture tastes about as salty as blood (which is about ½ the strength of full sea water). However, if possible, the sample can be sent to this office for determination. The sample should be taken with a bottle of reasonably small size which can be tightly sealed. To avoid sampling the water at the immediate surface, (which may be quite fresh on calm days of early summer), the bottle should be dipped, filled and closed a foot or so below the surface, or a bucket should be lowered a couple of feet below the surface and jerked to the surface and up onto deck.

7. Observations on Weather

The most valuable single weather observation which can be made, quite casually, by many northern residents is the number of calm days during the open water season. By calm days, we mean those days in which the wind is generally less than 3 knots (0 or 1 on the Beaufort Scale), and on which the water surface is never entirely ruffled. Such days could merely be ticked off on a calendar.

8. Weights and Measurements

More precise data are required, to verify some of the presumptions on pages 55-65. The important ones are:

A. Detailed body-part weights of ringed seals of known total weight.

B. Weights of the blubber of ringed seals of known total weight. The date must be given. The blubber should be scraped off the skin and removed carefully where it clings to the carcass.

C. More total and body-part weights of bearded seals of known length would be useful. Seals should be measured from tip of nose to tip of tail, in a straight line, with the head in a natural position (not stretched out).

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